THE TRANSITION IN AUSTRALIAN SCIENCE POLICY 1965-1990

by

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I affirm that this thesis contains no material which has been accepted for the award of any degree or diploma in any tertiary institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person except where due reference is made in the text of the thesis.

J. E. Homeshaw

ABSTRACT

The thesis is an explanation of the transformation of science policy in Australia between 1965 and 1990 using analytical constructs from policy analysis and political sociology to examine the way in which cultural, political, social and economic factors have influenced the course of decision-making about the production and application of scientific knowledge.

During these years science policy in Australia changed from being driven principally by notions of the creation and transmission of knowledge to being concerned with questions of economic production. Until the 1980s change was incremental rather than radical due to the conservatism of interest groups, the political ideology of significant actors in the policy community, and the political passivity of scientists.

In 1965 the production of scientific knowledge took place in the universities and a few large public research organisations and was externally non-accountable in terms of the utility of the knowledge produced. By 1990 the production of scientific knowledge has become the keystone of the government's hopes for turning Australia into a 'clever country' with the production of economic wealth based on knowledge and 'know-how' rather than raw materials. The rationale for the change is basically economic: scientific knowledge is considered necessary to supply the innovations upon which a broader system of economic production is to be based.

This change has brought into focus the relationship between the political system and the scientific system which forms the core of the science policy process. Politicisation of the science system occurs as the scientific community is drawn into the policy-making process and interaction between the two systems is formalised in new techno-political agencies. The organisation of the production of scientific knowledge, once the province of autonomous scientists, is increasingly under the control of central, corporatised political agencies.

A policy community approach, supplemented by concepts of power is the main analytical tool. This approach explains policy formulation and outcomes in terms of the interactions of interest groups. A policy community is seen as that part of a political system that - by virtue of its functional responsibilities, vested interests and specialised knowledge - acquires a dominant voice in determining government decisions in a specific field of government activity, and is generally permitted by society at large, and the public authorities in particular, to do so. Power is exercised in the policy community by organised interests with the capacity to control the resources, rules and ideas which underlie action in the policy arena. The dynamic which underlies action in the science policy community is that of the exchange of knowledge, resources and legitimacy.

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AUTHORITY OF ACCESS

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J.E.Hornershaw ......Date 16.6.94

Contents

ABBREVIATIONS

AAEC	Australian Atomic Energy Commission
AAS	Australian Academy of Science
AATSE	Australian Academy of Technological Sciences and Engineering
ABS	Australian Bureau of Statistics
ACPRRE	Advisory Committee on Priorities in Rural Research and Extension
AGPS	Australian Government Printing Service
AIRDGB	Australian Industrial Research and Development Grants Board
AIRDIB	Australian Industrial Research and Development Incentives Board
AIRDIS	Australian Industrial Research and Development Incentives Scheme
AIRDS	Australian Industrial Research and Development Scheme
AIRG	Australian Industry Research Group
ALP	Australian Labor Party
AMLRDC	Australian Meat & Livestock Research & Development Corporation
AMRAD	Australian Medical Researchand Development Corporation
ANAO	Australian National Audit Office
ANSTO	Australian Nuclear Science and Technology Organisation
ANU	Australian National University
ANZAAS	Australia & New Zealand Association for the Advancement of Science
ARC	Australian Research Council
ARGC	Australian Research Grants Committee
ARGS	Australian Research Grants Scheme
ASA	Australian Science Action
ASTEC	Australian Science and Technology Council
ATO	Australian Tax Office
AUC	Australian Universities Commission
AVCC	Australian Vice Chancellors' Committee
BERD	Business Expenditure on Research and Development
CBO	Committee of Budget Officials
CCRRE	Commonwealth Council on Rural Research and Extension
CHI	Computer Horizons Incorporated
CRC	Co-operative Research Centre
CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Organisation
CTEC	Commonwealth Tertiary Education Commission
DASETT	Department of Arts, Sport, Environment, Tourism and Territories
DEET	Department of Education, Employment and Training
DITAC	Department of Industry, Technology and Commerce
DPIE	Department of Primary Industry and Energy

ERC	Expenditure Review Committee
FASTS	Federation of Australian Science and Technology Societies
FAUSA	Federation of Australian University Staff Associations
GERD	Gross Expenditure on Research and Development
GIRD	Grants for Industry Reseach and Development
IAC	Industries Assistance Commission
IPC	International Patents Classification
IR&DB	Industrial Research and Development Board
IRSG	Industrial Research Study Group
MIAC	Manufacturing Industries' Advisory Council
L-NP	Liberal and National Parties
NBEET	National Board of Employment, Education and Training
NH&MRC	National Health and Medical Research Council
NIES	National Industry Extension Scheme
NPDP	National Procurement Development Program
NSTAG	National Science and Technology Advisory Group
RIRDC	Rural Industries Research and Development Corporation
RIRF	Rural Industry Research Fund
SCA	Standing Committee on Agriculture
SCI	Scientific Citations Index
SPRU	Science Policy Research Unit (University of Sussex)
TRACES	Technology in Retrospect and Critical Events in Science
UNS	Unified National System (of Australian tertiary education)

INTRODUCTION

This thesis is about science policy in Australia. Science policy can be defined as a set of decisions taken by a group of actors with authority concerning the selection of scientific research goals in the public arena and the means of achieving them. The science policy arena is a set of political relationships in which governments and scientists interact to provide the rules, resources, and ideas for the production of scientific knowledge, and its application and dissemination.

In Australia the principal arena of action in science policy is at the federal level. Since federation, the Commonwealth government has gradually assumed the major responsibility for the provision of public resources to the production of scientific knowledge, and by far the major proportion of such production in Australia is now funded at this level. In 1988-89 the Commonwealth government provided $1888m (0.61% of GDP) for research and development compared with $399m (0.12% of GDP) provided by the States.[1] Through such mechanisms as the establishment of the Council for Scientific and Industrial Research (CSIR) in 1926; the National Health and Medical Research Council (NH&RMC) in 1937; the creation of subsidised trust funds for rural research in the 1950s; the takeover of university funding in 1958 and the setting up of the industrial research grants scheme in 1967; the focus of control has passed from State governments to the Commonwealth government. In 1968 the State governments' share of research expenditure was 13 per cent. By 1988 this had decreased to 11 per cent.[2] This thesis therefore focuses on the interaction between the science system and the political system at the federal level. Discussion of the involvement of State governments in the production, dissemination and application of scientific knowledge is confined to the role of State governments as producers and users of such knowledge. The formulation and implementation of science policies by individual State governments is not under consideration here.

In Australia too, most research and development is both funded by, and undertaken within, the public sector. In 1988-89 only 40 per cent of expenditure, and 30 per cent of researchers and support staff, were from the private and private non-profit sector.[3] The USA tradition of private, independent laboratories undertaking research work for public and private sponsors did not develop in Australia. Apart

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1 Australia, *Science and Technology Budget Statement 1991-92,* Budget Related Paper no. 6, AGPS, 1991, p. 101
Department of Industry, Technology and Commerce, *Australian Science and Innovation Resources Brief,* AGPS, Canberra 1992, p. 3.

2 The years 1968 and 1988 are used because, in the twenty-five year period 1965-1990, these are the earliest and latest years for which comparable data are available.
Department of Science, *Project Score,* Report 5, Summary of all expenditure by Australia on research and development during 1968-69, AGPS, 1973, Table 2, p. 10;
ABS, *Research and Experimental Development All Sector Summary 1988-89,* Cat no. 8112.0, 1990, Canberra, Table 4, p. 4.

3 Ibid., pp. 4-5.

from a few privately funded research laboratories in the rural and mining industries, and equally few (and highly prestigious) private medical research institutes, the vast majority of public funds spent on research and development in Australia are for work undertaken in public sector research organisations or private firms. Even these private facilities are, to a greater or lesser degree, subsidised by governments. The thesis therefore concentrates on decisions made in the public arena but includes publicly funded research and development undertaken in the private sector.

Four main areas of science are examined: higher education; research undertaken in the Commonwealth Scientific and Industrial Organisation (CSIRO); rural research; and research for manufacturing industry. These areas have been chosen because each has developed a distinct type of relationship between political actors and researchers. Researchers in the higher education system regard themselves as being at the frontiers of knowledge which may not have any practical value but is of intrinsic value. CSIRO has for many years been the Commonwealth Government's 'principal instrument for civilian research' and therefore requires close scrutiny in an analysis of science policy in Australia.[4]

Research for manufacturing industry has long been the problem area of Australian science policy because it confronts governments with the issue of intervention into market relationships. In contrast, research for rural industry has traditionally been collectivised, legitimated and subsidised by governments in Australia. These two areas of research invite comparison because of the discrepancy between the traditional reluctance of governments to intervene in the private sector management of research in manufacturing industry and the willingness to subsidise rural research and to prioritise between rural industries through differential rates of subsidisation.[5] Rural industries were always seen as the traditional source of wealth creation in Australia: manufacturing industries were not.

The thesis does not cover the relationship between government and other areas of science in Australia. Decisions about health and defence research have, in Australia, traditionally been made in isolation from other areas of research, and have been considered as part of health and defence policy respectively. Defence research has been isolated from other areas of research since the Menzies 'Red Scientists' scandal caused such work to be split off from CSIRO in 1949. Not until 1993 was the decision been made to subject health research to the same economically-based evaluation criteria as other civilian research.[6] Both areas have remained opaque to

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4 Guy Gresford, *The Organisation of Science Policy in Australia,* Public Policy Paper no. 7, Department of Political Science, University of Tasmania, 1976, p. 6.

5 For example, in 1963-64 the Commonwealth Government contribution to wool research (4s per bale) was twice the growers' contribution (2s per bale); whereas the Government's contribution to wheat research simply matched that of the growers.
Committee of Economic Enquiry. *Report 1965,* vols. 1 & 2, (Sir James Vernon, Chairman), Parl. Papers 371 & 372, Canberra, 1965 p. 676.

6 Dr Michael Pitman (Chief Scientist), Address, Australasian Association for the History, Philosophy and Social Studies of Science Conference, La Trobe University, July 10, 1993.

government scrutiny. Reference to these areas of scientific production will be made only when policy changes in these areas impact on the areas under consideration. There are other areas and institutions of science which, because of constraints of space, are considered only in passing. These include Antarctic, marine, energy and mining research; and the associated institutions and programs.

Temporal Points of Reference

Policy arenas are historically dynamic systems of action. The choice of a period for analysis must recognise that prior events are important in defining interaction in a policy arena; and that change continues beyond the specified time boundaries of an analysis. Nevertheless, analysis of change in a policy arena needs temporal containment in order to restrict the scope of substantive issues under consideration to a level which is manageable and meaningful in terms of the analytical approach which is used.

The years 1965 and 1990 have been selected as temporal boundaries of the thesis because they can be considered as watersheds in the history of science policy in Australia in terms of control over the public resources allocated to the production of scientific knowledge. In each year there were significant policy events which were the culmination of both incremental and radical changes in the relationship between the Commonwealth government and scientists. Each year was the penultimate one in the tenure of a Prime Minister who had developed an interest in science policy. Menzies' interest dated from the formation of ANU in 1945-46 whereas Hawke's interest developed late in his prime ministership. Each man chose to locate ministerial responsibility for science policy within his own portfolio, and to bring scientists into the core of executive government.

In 1965 science policy was emerging as a coherent set of issues which had to be explicitly addressed by politicians. Menzies made a speech in Parliament which acknowledged for the first time that political actors should make decisions about the directions in which scientific research should proceed.[7] The Martin Report on Higher Education (1965) and the Vernon Report on economic policy (1965) had both made explicit recommendations for restructuring the production of scientific knowledge in Australia.[8] 1965 was the last year of State governments' responsibility for research in universities and the last year of government non-intervention in manufacturing industry research. The era in which the relationship between government and individuals in the scientific community was conducted through informal, ad hoc interaction was ending because of pressures on political leaders from political opponents and some prominent scientists, and because of new ideas about the

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7 Australia, House of Representatives 1965, *Debates,* vol. HR 46, pp. 267-274.

8 Committee on the Future of Tertiary Education in Australia, *Report,* 3 Volumes, (Sir Leslie Martin, Chairman), Government Printer, Canberra, 1965.
Committee of Economic Enquiry. *Report 1965.*

relationships between governments and science which were being formulated throughout the western world.[9] The Deputy Leader of the Opposition, Gough Whitlam, had observed the way in which Harold Wilson had used the issue of technological development as a stepping stone to political power in the UK.[10] He used similar issues to harangue the Liberal-Country Party Government over its lack of coherent policy for science and technology. The scientific community in Australia was split over the issue of whether to institutionalise scientific advice to government with its attendant risk of loss of scientific autonomy.

By 1990 science policy was confirmed as a significant policy arena by being selected by the ALP to open its election campaign. The concept of 'the clever country', underpinned by scientific research and increased education, was front page news throughout Australia.[11] For ten years, seven of them in government as Minister for Science, Barry Jones had been proselytising the need to redress the technological balance of payments between the Australian economy and the rest of the world by developing science-based industries. The absorption of the Department of Science into the Department of Industry, Technology and Commerce in 1987 emphasised the Hawke Government's commitment to realign the production and application of scientific knowledge with non-rural economic production

The restructuring of the production of scientific knowledge necessary to achieve this objective threatened existing networks of the control of resources and institutions and caused scientists to become involved in political activity. For example, as the first Hawke Government enlarged the membership of the Australian Industry Research and Development Incentives Scheme (AIRDIS) Board, and the Australian Research Grants Committee (ARGC), to include industry representatives with marketing expertise, particularly in the new biotechnology and computer industries, the influence of researchers in traditional disciplines, and of their academies, was diluted. Their response was the establishment of the Federation of Australian Scientific and Technological Societies (FASTS) in 1985 as an overtly political lobbying organisation, and of the National Science and Technology Advisory Group (NSTAG) as a scientist's 'think tank' on science policy.

Similar restructuring involved the redefinition of the industrial role of CSIRO in an 1986 legislation amendment; the cutback in direct appropriation funds to force the Organisation to seek more external sources of funding; and the encouragement of a market-oriented ethos within the CSIRO Executive. These changes threatened the much-prized autonomy of CSIRO researchers. They formed their own lobbying

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9 For example, the establishment of the OECD in 1961 included a science and technology section which advised member countries on their science policies. The USA and the UK governments had appointed scientific advisers. The journal *Minerva* was launched as an academic forum for discussion on science policy. Chapter 3 discusses in detail the awakening of such ideas and their reception in Australia.

10 The Honourable William Morrison, Interview, 8 November 1989.

11 'PM $776m to build "a clever country", *Australian,* 9 March 1990, p. 1.

organisation - Australian Science Action - and used such pressure group techniques as mass rallies, saturation correspondence to print media, the co-option of journalists and direct lobbying of significant political actors, to embarrass the Government electorally.

The Hawke Government counter-responded by issuing a major policy statement on science and technology in 1989, by introducing an annual science and technology Budget Paper, by appointing a Chief Scientist in the Department of Prime Minister and Cabinet, and by establishing a Prime Minister's Science Council and a permanent interdepartmental co-ordination committee. These measures created a new stratum of relationships in science policy-making.

Analysis of policy changes between these two distinct years, separated by twenty-five years of continuing action, must take into account policy changes throughout the intervening period and the reasons for such changes. In the thesis chronological analysis of policy changes is organised according to sectoral divisions in science policy because each sector demonstrates varying patterns of change. Although the pressures for change were experienced by all sectors, change was manifest differently in each sector. In order to explain the changes and to account for the differences the thesis also examines the way in which rules (structures), the allocation of resources, and the ideas underlying policy action, change in each of the four selected areas of the science system.

THE MAIN EMPIRICAL ARGUMENT OF THE THESIS

The purpose of the thesis is to examine the extent to which science policy changed between 1965 and 1990. The main empirical argument is that there has been a radical shift in the objectives of science policy and the way in which governments have sought to realise these objectives. Therefore a major task will be to discern the direction of change; to analyse the factors which have brought about such change; and to identify changing science policy outputs. It is not the purpose of this thesis to evaluate the efficacy of such outcomes.

In 1965 the principal objectives of producing scientific knowledge were cultural, and educational, and these were achieved by allocating resources to largely autonomous research organisations and institutions. Until 1964 there was only a Minister-in-Charge, CSIRO. Portfolio responsibility for research was then given to a Minister Assisting the Prime Minister in Education and Research. There was no formal policy mechanism for interaction between the scientific community and significant political actors. Advice and negotiation about the allocation of resources occurred on an ad hoc basis between the principal scientists of each sector and political actors. There was no coherent linking of the publicly-funded production of scientific knowledge and national socio-economic policy objectives.

Within the higher education sector the objectives were the training of new scientists and the production of basic scientific knowledge to maintain Australia's position in the international scientific community. Resources were allocated to individual universities through recurrent grants, and to individual researchers through competitive grants based on the excellence of the research project rather than the country's need for the results of such research. The amount and type of applied science of direct relevance to industry produced in universities depended on the entrepreneurship of individual scientists vis à vis local industries. In 1968, 76 per cent of all research conducted in higher education institutes was basic science. Only 20 per cent was applied and 4 per cent was developmental.[12]

In 1965 the objectives of CSIRO were explicit in the name of the Organisation - Commonwealth Scientific and *Industrial* Research Organisation. The Organisation was empowered to 'initiate and carry out' scientific research for the promotion of 'primary or secondary industries'. However, the 1949 amendment to the 1926 Science and Industry Act had diluted the Organisation's statutory obligations actively to disseminate the results of its research to industry.[13] It seems to have been assumed that CSIRO scientists would automatically align their research with the needs of industry and that such accountability mechanisms as statutory requirements were unnecessary. Annual appropriations for the Organisation were reported outside any portfolio in the same way as the Attorney General's Department.

Within the manufacturing industry research sector the interaction between the Commonwealth government and producers was virtually non-existent. There was as yet no direct subsidy to industry for manufacturing research. Such organisations as the Australian Industry Research Group (AIRG) and the Institution of Engineers had been unsuccessfully lobbying the Menzies Government for several years to adopt the Canadian policy of allowing tax concessions of 150-200 per cent on research activities. The Committee of Economic Enquiry, in its comprehensive and detailed analysis of economic policy in Australia, in 1965 made a strong case for the active promotion, by government, of innovation through research and development.

The situation for rural industry was very different. The joint funding of research and development by industry associations and governments had become institutionalised by 1965. Research for the wool, wheat, dairy and meat industries was subsidised through a system of trust funds comprising compulsory levies imposed on producers through the taxation powers of the Commonwealth government, and matched to varying degrees with public funds. The research results thus obtained had the status of a public good distributed at public expense through a system of extension services to rural producers.

In general therefore, governmental objectives for science in 1965, apart from rural research, were broadly focused on nationalistic and cultural issues. Research organisations were created and maintained as much to provide evidence of national

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12 Department of Science, *Projects Score*, Report 3, Summary of all expenditure by Australia on research and development during 1969, AGPS, 1974, Table 7, p. 31.

13 Science and Industry Research Act, no. 13 of 1949, Part II, section 9, subsections (a) and (g).

esteem or colonial loyalty as to assist in economic production.[14] Management of the role that scientific knowledge played in national economic production was considered by government to be the responsibility of scientists and producers. Governments maintained a flow of funds, legitimated scientists' activity through state sponsorship, and left the organisation of research and development to the scientists. In contrast, governmental objectives for science in 1990 were finely focused on the application of scientific knowledge to national economic production. Technical and political rationality had replaced scientific rationality in the organisation of research and development. Decision-making in the allocation of public resources to science was based on techno-economistic criteria rather than the criteria of scientific status.

Thus, by 1990 the main focus of science policy objectives had become the restructuring of economic production towards research-based industries. Interaction between the Commonwealth government, researchers and producers towards achieving this outcome is co-ordinated through a variety of formal mechanisms including advisory committees, inter- and intra-departmental committees, research funding agencies, and departmental science advisers. Researchers and research organisations are increasingly being held accountable for the public funds they use. Since 1989 a separate Science and Technology Budget Paper has been published giving details of financial resources allocated to research and development in all Commonwealth government portfolios. Parliamentary scrutiny of the allocation of resources to research agencies has been undertaken through the Australian National Audit Office and the Joint Committee of Public Accounts. The autonomy of public sector scientists to select research projects, and to disseminate to the international scientific community the results of their work, is being constrained by selection and evaluation criteria which align publicly-funded research with potential economic gains, and by new approaches to the issue of intellectual property.

Within the four areas of science covered in detail in this study the change in science policy can be observed in four distinct dimensions of the organisation of the production of science: the allocation of public financial resources; the restructuring of research organisations; the selection and evaluation of research projects; and the type of knowledge produced and its application. In the higher education sector the abolition of the binary system widened the research base of higher education and increased the competition for research resources which are increasingly allocated on a team rather than an individual scientist basis. Research in basic science is channelled into areas of potential economic benefit by the transfer of recurrent research funds to the competitive grants system; the widening of the membership of selection committees; and the inclusion of criteria of selection which include market skills and

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14 Between 1950 and 1965 the most significant developments in the science system in Australia were the establishment of the Australian Academy of Science, the expansion of basic research facilities at the Australian National University, and increased expenditure on the Weapons Research Institute which was directly associated with the British nuclear weapons program.

values. In 1988 basic research accounted for 63 per cent of all scientific work in universities; applied research for 31 per cent and developmental research for 7 per cent.[15]

Restructuring in CSIRO has resulted in a corporate executive structure with individual divisions grouped in industry-aligned institutes. In 1990 the first-ever appointment of a Chief Executive from the private sector emphasised the Commonwealth government's commitment to orient the Organisation's work more closely to market needs. The government held constant the proportion of funds allocated to the Organisation by direct appropriation and forced scientists to seek external funding. A universal system of research prioritisation was developed within CSIRO to be used by researchers who were encouraged to think of their work more in terms of its commercial application in Australia than its importance within the international scientific community.

In the sector of manufacturing industry, successive Commonwealth governments have gradually accepted the need to intervene in the process whereby scientific knowledge is produced in order to assist the innovation process. The shift has been from a situation in which governments subsidised a narrow range of activity labelled 'research and development' to one in which the range of eligible activities has broadened. This has involved the differentiation of subsidies from the Government to enable firms of different sizes, stages of growth and type of technology to undertake or fund a range of research from basic-type, generic science to research into the commercialisation of new products or processes. So, for example, generic grants generate scientific knowledge which can be used by a range of firms at a pre-competitive stage, and discretionary grants encourage small firms with no previous research experience to perceive research activity as an essential route to innovation. The 150 per cent tax concession on research and development, introduced in 1986, is a recognition by government that firms need flexibility, autonomy and the capacity to act quickly in order to capture new markets: characteristics often constrained by the necessary bureaucracy of grants schemes.

In rural industry, where the collective funding of research has been well-established, the techno-economic imperative has meant a shift from the prioritisation by scientists and producers of research projects generating universally available knowledge, to one in which research corporations undertake studies of potential market niches and only then design research projects which will result in new products or processes to fit that niche. Within such public sector research organisations as CSIRO, in which a great deal of rural research projects were not funded collectively, the cutback in appropriation funds and the need to raise funds externally has led to a reduction in the amount of research formerly considered to be a public good. These

15 ABS, *Research and Experimental Development All Sector Summary 1988-89,* Table 6, p. 5.

organisational constraints, together with the changing nature of intellectual property in biotechnology, have led to increasing privatisation of rural research.

One consequence of these changes in science policy is that actors who previously benefited from the traditional approach to the production of scientific knowledge find that their interests are now threatened. Scientists who enjoyed considerable organisational autonomy over the conduct and direction of research, and over the dissemination of the results of their work, find their resources diminishing unless they accept political and economic norms of accountability not formerly applied to them. Independent rural producers find that extension and laboratory services formerly provided free of charge by the State are now only available through the marketing of agribusiness firms' products and processes. CSIRO researchers who pursued international recognition now find that divisional resources are allocated to them according to criteria based on the commercial potential of their work within Australia. These actors have become politically involved in recent years in order to protect their interests. They have done this by forming new representative organisations, such as FASTS and Australian Science Action, which are concerned with lobbying governments about scientists' interests rather than with promoting academic status.

These changes have occurred largely out of the spotlight of electoral and parliamentary scrutiny. Examination of political action within the formal institutions of government would yield only partial understanding of the transition in science policy. Therefore, in order to examine in detail the changes in science policy, and the policy outcomes in terms of the policy actors and their behaviour, it is necessary to use an analytical approach which allows the identification of significant individual and organisational actors across political and sectoral boundaries; how they perceive and defend their interests; and an explanation of the way in which their actions shape policies.

THE ANALYTICAL APPROACH

The analytical approach used in the thesis is that of the policy community. The policy community approach is based on pluralistic concepts of interest groups attempting to influence the allocation of societal resources by interacting with governments. Such insights have been used in policy analysis since 1939, but it is only in recent years that policy community theory has become a distinct tool of analysis.[16] The approach is still in the process of development with such writers as Jordan, Rhodes, and Wright in the UK, and Atkinson, Coleman, Pross and Skogstad in Canada, refining the concept and testing its utility through the analysis of policy in a variety of arenas. This thesis adds to that increasing body of knowledge in two ways: by refining further the

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16 Grant Jordan, 'Subgovernments, Policy Communities and Networks: Refilling Old Bottles?', *Journal of Theoretical Politics*, vol. 2, no. 3, 1990. pp. 319-338.

analytical categories of actors to clarify their location and significance in the policy community; and by introducing concepts of power from political sociology to inform the analysis of interaction among policy actors.

The thesis is organised on the basis that policy communities consist of actors, with control over rules (the action structures of institutions), resources and ideas, in specified arenas of action, making decisions about achieving outcomes. Science policy is decided principally in two arenas of action: the science system and the political system. Action in the science system centres on the production of scientific knowledge; and political action centres on the authoritative allocation of values to achieve social objectives. The key concepts underlying these assumptions are discussed in chapter one. The analysis of science policy is essentially an analysis of interaction between these two social systems within an Australian economic and institutional context and a global economic context.

The production of scientific knowledge in the science system, and the authoritative allocation of values in the political system are society specific in that the institutional context of action will vary from country to country according to the way in which the relevant institutions have developed through time. So, for example, the science system in Australia, which has been influenced greatly in its development by the science system in the UK, has had to adapt to a federally administered political system in a large, sparsely populated country geographically isolated from the rest of the English-speaking world. Both systems of action exist in a global economic environment in which goods and services are produced and exchanged with varying degrees of openness. These social, political and economic contexts and the ideologies informing them are described in chapter two.

A policy community approach developed from the ideas of Richardson and Jordan in the early 1980s is used to identify the key actors and groups of actors who make science policy decisions. To Lowi's notion of the universality of homogeneous, easily defined interest groups in a society are added concepts of corporatism as representative monopoly, and the understanding that 'the public interest' is therefore the sum of pressure groups active on a particular issue. Government then becomes 'the management of a complex environment through the co-operation of mediating institutions'.[17] This approach allows an analysis in the science policy context which cuts across the boundaries of individual organisations in both subsystems of action. It also allows an analysis which recognises that certain policy arenas are influenced by individuals, groups and organisations beyond national boundaries.

Such writers as Pross, and Coleman and Skogstad, refined the approach by saying that a policy community is composed of a subgovernment of actors authorised by governments to make decisions or provide advice, and an attentive public which

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[17] J. Richardson & G. Jordan, *Governing under Pressure: The Policy Process in a Post-Parliamentary Democracy,* Martin Robertson, Oxford, 1979, p. 158.

attempts to influence those decisions.[18] Such actors interact through policy networks which are defined as the structural arrangements which develop over particular issues among a set of actors sharing a common policy focus. These networks can be categorised according to the degree to which actors are organised, the capacity of non-government actors to co-ordinate their activity, and the relative autonomy of both public and private actors. Policy networks develop and change as particular issues wax and wane in importance within a policy community.

Policy networks can also exist across national boundaries. Most policy community writers discuss the influence of international interaction on policy-making in certain arenas. Science policy is one of these arenas because the norms of the science system emphasise that the production of scientific knowledge should be considered an international rather than a national phenomenon. The ideas of international influence on policy communities mentioned by Pross, Coleman and Skogstad, and Atkinson and Coleman are especially relevant here. This thesis therefore introduces the concept of an *international attentive public* which is influential in Australian science policy-making. The Organisation for Economic Co-operation and Development, and the Science Policy Research Unit at the University of Sussex are two organisations which would be included in the international attentive public for science policy in Australia.

The thesis also questions the use, in policy community literature, of the notion of 'a subgovernment' in the absence of a defined category 'government'. If policy community writers use the prefix 'sub' to mean 'a subset of' government rather than 'subordinate to' government, there must logically be a category of actors external to the policy community but internal to such institutions as Cabinet and central agencies. This thesis therefore specifically includes a category designated as the *executive core* to include those actors who are part of the central agencies of government, who do not act within a specific policy community but who have the capacity to veto action within a policy community. The concepts of the policy community approach are discussed in chapter one and are used throughout the thesis, but particularly in chapters three and four to analyse the organisation of science policy and the ideas informing it.

Another aspect of the policy community approach which is deficient is the explanation of power in the policy process. Atkinson and Coleman state that the two key questions of policy analysis have become: 'who participates and who wields power.'[19] Nevertheless they do not consider the exercise of power *per se* as one of

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18 A. P. Pross, *Group Politics and Public Policy,* 2nd edn., Oxford University Press, Toronto, 1992.
William D. Coleman & Grace Skogstad, *Policy Communities and Public Policy in Canada: A Structural Approach,* Copp Clark Pitman Ltd, Toronto, 1990.

19 The variables are:
- the issue of boundary shifts between and within policy communities;
- recognition of the importance of political ideas;
- shifts in the political and socio-economic environment.

the three critical variables which must be explored in the development of the policy community approach. Rhodes considers policy communities as part of power-dependence relationships in societies but sees power as a medium of exchange for resources and not part of the process of controlling both the structures of exchange and the media exchanged.[20] This thesis directly addresses the question of how actors in policy communities exercise power. The exercise of power is seen as a crucial dynamic in policy community interaction.

The concepts of power which explain most fully notions of resource dependency and the domination of decision-making within a policy community are those developed separately by the political sociologists Giddens and Clegg.[21] The concepts are discussed in chapter one. The notion that power is both emergent from, and generative of the rules, resources and ideas of interaction in a policy community is used to organise the substantive analysis of change in Australian science policy which forms the core of the thesis. The actors, groups of actors and organisations which comprise the science policy community will use their control over the resources, rules and ideas of political action and the science system in order to achieve outcomes favourable to their interests.

Control over the rules of the production of scientific knowledge is discussed in chapter three in terms of the organisation of science policy. Access to crucial decision-making forums enables actors to shape policy to fit their interests. The decision-making structures which are established, and which develop and change, reflect the interests and ideologies of key actors in the different subgovernments of the policy community. The actors who control and influence the decision-making structures of the science policy community use ideas from a variety of sources to justify their actions. In the science policy community scientists draw upon norms and values described in the writings of such sociologists as Merton and Storer, and such political scientists as Polanyi and Peres, to defend the autonomy of research organisations.[22] Ideas in the political system may derive from political ideology, and from economic

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Atkinson & Coleman, 'Policy Networks, Policy Communities and the Problems of Governance' pp. 58 & 172-176.

20 R.A.W. Rhodes, *Power Dependency, Policy Communities and Intergovernmental Networks,* Essex Papers on Politics and Government, no. 30, Department of Government, University of Essex, September 1985, p. 3.

21 Anthony Giddens, *Central Problems in Social Theory: Action, Structure and Contradiction in Social Analysis,* Macmillan, London, 1979, p. 69-70.
Stewart R. Clegg, *Frameworks of Power,* Sage Publications, London 1989.

22 Robert K. Merton, 'Studies in the Sociology of Science', in *Social Theory and Social Structure ,* The Free Press, New York, 1968, pp. 585-681, p. 611.
Leon Peres, 'The Science of Being Important', *The Australian Quarterly,* vol. XXXIX, no. 1, March 1967, pp. 28-37.
Michael Polanyi, 'The Foundations of Academic Freedom', *Australian Journal of Science,* vol. XI, no. 4, February 1949, pp. 107-115.
--'The Republic of Science', in *Criteria for Scientific Development,* ed. Edward Shils, The MIT Press, Cambridge, Massachusetts, 1968, pp. 1-20.
Norman Storer, *The Social System of Science,* Holt, Rhinehart & Winston, USA, 1966.

theories of innovation and market failure to justify government actions. These ideas are discussed in chapter four. The discussion is organised along two dimensions: ideas about government objectives for scientific research; and ideas about who should exercise control over the organisation of research.

Decisions are made by and for the science policy community in the expectation that certain outcomes will eventuate within the subsystem of science. Control over the public resources allocated to the production of scientific knowledge is both part of the formulation of science policy and one of its outcomes. The expenditure of public funds reflects political ideologies about the way society should be, and the influence that certain actors have over the decisions about the allocation of public resources. Analysis of the changing patterns of resources allocated to and within the science system allows the analyst to measure the fit between science policy rhetoric and science policy reality. Chapter five compares patterns of expenditure on the production of scientific knowledge in 1965 and 1990 and highlights significant events which affected the patterns of allocation.

Chapter six, seven and eight discuss three aspects of the way in which scientific knowledge is produced, in order to measure the impact of changing policy upon the production and application of scientific knowledge. These aspects are: the structure of research organisations and programs; the selection and evaluation of research programs; and the type of knowledge produced and its application. The norms and values of science advocate the autonomy of the individual research worker to undertake a program of research. The traditional belief among scientists is that good science emerges from rigorous application of the scientific method to areas of interest and concern to scientists and others. Scientists believe that the progress and results of such scientific work cannot be predicted. Hence researchers should be allocated resources and allowed to produce results which may often be serendipitous. The norms of political and economic accountability should apply only loosely to the production and application of scientific knowledge, and to the institutions in which research is undertaken.

Political actors have different and changing expectations of the science system which are in conflict with the norms and values of science. The notion that scientists should be accountable to the public for the funds they consume, the knowledge they produce and the use to which that knowledge is put, may result in very different modes of organisation for research. Still further removed from the norms of science is the proposition that non-scientists should decide, or even participate in decision-making about which research is to be undertaken. The idea that the knowledge which results can be owned, bought and sold in the same way as any other commodity is anathema to the traditions of science. Science policy therefore is an arena of potential conflict between two systems of action based on different values. The outcomes of science policy are to a large extent the result of the way in which the two systems of action interact and negotiate control of the rules, resources and ideas of the science policy community.

This proposition is fundamental to the entire thesis but is discussed in detail in chapters six seven and eight. Chapter six analyses the way in which changing ideas about research have been realised through the restructuring of research organisations and funding programs. Chapter seven discusses how new techniques for the prioritisation, selection and evaluation of research projects have been introduced in the four sectors of the science system, and examines the extent to which their introduction was resisted by the scientific community. Chapter eight focuses on the principle product of the science system - new scientific knowledge - and examines the changing role of government in the application of research results.

The thesis contributes to policy analysis in Australia at two distinct levels: by continuing to develop the policy community approach to analysis; and by introducing into the empirical analysis of science policy variables not previously considered. Firstly, it adds to the policy community literature by expanding the concepts of attentive public and subgovernment to include international actors, actors within the executive core of national governments, and the new stratum of superstructural subgovernments. Secondly, it continues the work of Coleman and Skogstad in testing the capacity of the policy community approach to explain policy change through time by examining the causes and dynamics of change in policy communities. Thirdly, it adds to the approach an explanation of how certain actors dominate policy formulation and implementation through the exercise of power in the form of control over ideas, rules and resources. Fourthly, it uses these concepts of power to examine variables not previously considered in the analysis of science policy in Australia. By explicitly examining the relationship between political ideology and science policy outcomes, the thesis shows that it is possible to predict the way in which science policy will develop as political values (expressed as objectives for the science system) change.

This relationship is demonstrated empirically through analysing changing patterns of control over the way in which rules, resources and ideas are established, allocated and introduced into the science policy community. All three variables are interdependent. Control over structures and the rules of interaction allows control over membership of key decision-making bodies, the resources they allocate and the ideas by which policy initiatives are translated into outcomes. Control over resources allows control over the capacity to introduce new forms of interaction and the way in which new ideas are operationalised. Control over ideas allows key actors entry into significant decision-making agencies and therefore influence over the way in which new structures of interaction and resource allocation replace old ones.

Over the twenty-five year period under consideration considerable empirical change is observable within the science policy community. Examination of these three variables through time allows the analyst to identify definite patterns of change and to identify their probable causes. This analysis can then be used to predict future patterns of action as policy actors attempt to impose particular ideologies on the science policy community in order to protect their particular interests.

SOURCES OF EVIDENCE

The thesis uses information from a wide range of sources. Interviews were conducted with fifteen key actors in the science policy community.[23] These include: the Chief Scientist; the Chairman of the Science Policy Committee of the Australian Academy of Science(AAS); a CSIRO divisional Chief; the Chairman of the Board of the Australian Nuclear Science and Technology Organisation (ANSTO); a former Minister for Science; two key decision-makers in the Department of Industry, Science and Technology; a member of the Australian Science and Technology Council (ASTEC); and several scientists with experience both in manufacturing and higher education.

During a long visit to the UK I had access to the libraries of Cambridge University and the Science Policy Research Unit at the University of Sussex where I also attended seminars on science policy and discussed relevant issues with the researchers there, some of whom had been part of the Australian science policy community. Empirical data in the public domain and information about the way in which it is compiled were obtained from such government agencies as the Australian Bureau of Statistics; the Patents Office and Commonwealth government departments; and from CSIRO. Parliamentary Papers were used as a source of Annual Reports; Budget Papers; Reports of Government Enquiries, and Auditor-General's Reports. Hansard is used to link policy decisions and action with political rhetoric, and to trace the actions of political actors. Journals of science and science policy; and magazines of the science system such as *CoResearch* and *Scitech* were scrutinised for insights into the workings of the system. Social directories such as *Who's Who* provided knowledge about memberships which was useful in tracing membership of the science policy community. Such private organisations as the Australian Industry Research Group; Attica; and FASTS supplied information about their organisations. Biographies and autobiographies of key actors yielded information about action, careers and personalities. Finally, informal and unplanned contacts with scientists in such places as aeroplanes and university cafeterias often provided valuable background perspectives on science policy issues.

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[23] Unfortunately this did not include Barry Jones, Minister for Science 1983-1990, whose busy schedule did not coincide with interstate field research trips. Fortunately Jones has written widely on science policy before, during and since his term of office.

CHAPTER 1

KEY CONCEPTS IN THE ANALYSIS OF SCIENCE POLICY

This chapter discusses the concepts from policy studies and political sociology which will be used in this analysis of science policy in Australia. The chapter begins with a definition of science policy which stresses the importance of individual and organisational actors and the decisions they make in particular arenas of action. The primary analytical approach used is that of the policy community, a relatively new concept, the development of which is traced and amplified with new insights into the categorisation of actors and the way in which they exercise power.

The thesis argues that the actions of key actors and groups are informed by ideologies which must also be identified in order to understand action in the policy community. Particular attention is paid in this chapter to concepts which can clarify and explain ideologies informing the actions of scientists Political ideology is discussed in chapter two The chapter concludes with a reiteration of the key concepts in a frame of reference for the thesis.

1. SCIENCE POLICY DEFINED

The definition of science policy to be used here is an adaptation of one used by Jenkins to define public policy in general. Jenkins uses a definition created by G. K Roberts' because it: '...captures the detail and density of the activities embraced by the political arena'.[1] The definition reads:

> A set of interrelated decisions taken by a political actor or group of actors concerning the selection of goals and the means of achieving them within a specified situation where these decisions should, in principle, be within the power of these actors to achieve.[2]

The definition is used because it offers the analyst an understanding of the elements and variables which must be examined in order to explain public policy. The idea of 'interrelated decisions' leads to the examination of relevant decisions through time and institutional space. The identification of individual actors or groups of actors is essential in understanding the environment in which decisions are made, and identifying the interests of those who make and influence the decisions. The concept of power, often lacking in definitions of public policy, allows the analyst to examine the social stratification of policy arenas in terms of the capacity to achieve action and outcomes favourable to certain interests.

Using Roberts' definition of public policy as a base, science policy is defined as:

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1 W.I. Jenkins, *Policy Analysis: A Political and Organizational Perspective,* Martin Robertson, London, 1978, p. 13.

2 Quoted in ibid., p. 15.

> A set of interrelated decisions taken by a political actor or group of actors with authority concerning the selection of goals and the means of achieving them within a policy arena in which governments and scientists interact to provide the rules, resources and ideas for the production and application of scientific knowledge. These decisions should, in principle, be within the power of these actors to achieve.

2. The Concept of Policy Community

The notion that governments enact policies which are as much the reflection of the individuals and organisations which produce them as they are the reflection of public choice, societal needs or political parties' platforms, has been in currency in policy studies since 1939 when Griffiths exhorted students of the policy process to examine the 'whirlpools of special social interest and problems' which surround the formal institutions of political systems.[3] Griffiths perceived that policy-making structures are based on specialised knowledge and the desire to influence policy decisions in order to protect or prosper certain interests rather than the constitutional status of the policy participant. Also in 1939, in Britain, Sir Ivor Jennings wrote of the parliamentary process that:

> ...much legislation is derived from organized interests... most of it is amended on the representation of such interests, and... often parliamentary opposition is in truth the opposition of interests.[4]

As the density of government activity burgeoned after the Second World War, political scientists began to see that the concept of groups of individuals or organisations with common interests, acting together to influence government policy, could be a useful analytical tool to explain the increasingly complex relationships between government and society in liberal democracies.[5] The concepts of policy network and policy community arose out of two broad streams of ideas about the policy process. These were the idea of pluralist pressure groups which developed in Britain and the USA, and the post-pluralist reaction which followed.

2.1 Pressure groups

The development of pluralism is documented by Richardson and Jordan (1979) and Jordan (1990). They attribute the articulation of the dynamic which gives rise to the political activity of organised interests to E. Pendleton Herring in the USA who argued that such groups arise because:

> ...the more the government becomes involved in controlling industrial and commercial interests, the more those interests must be allowed to participate in and indeed to consent to policy changes.[6]

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3 E.S. Griffith, *The Impasse of Democracy,* Harrison-Hilton, New York, 1939, p. 182.
4 Quoted in J. J. Richardson & A. G. Jordan, *Governing under Pressure*, p. 158.
5 Ibid., p. 159.
6 Ibid..

Within this idea are elements not only of government intervention and group opposition, but also of the legitimacy of group participation in the policy process and of the non-viability of policies which are not acceptable to organised non-governmental interest groups. Beer, in his study of British pressure groups, refined these ideas into his concept of 'new group politics' in which policy emerged out of a process of bargaining between governments, producer and consumer groups.[7]

In the USA Freeman combined the concepts of interest groups and systems theory to produce his notion that policy is made within subsystems of the political process. Subsystems are:

> ...the pattern of interactions of participants, or actors, involved in making decisions in a special area of public policy...although there are obviously other types of subsystems, the type which concerns us here is found in an immediate setting formed by the executive bureau and congressional committees with special interest groups intimately attached.[8]

Freeman here places his notion of the interaction of executive, parliamentary and interest group interaction in a political process which allows the actors relatively free access to the decision-making processes of government.

Lowi sees the process as one of homogeneous groups of organised interests, representing every facet of social life, bargaining with each other over competing claims to public resources. The role of government in this situation is one of ensuring fair access to the bargaining process.[9] Lowi developed this notion of the invasion of the public domain by private interests and their expropriation of decision-making structures and hypothesized that the process is one of coalescence into a triangular situation of dependency between central agencies, congressional sub-committees and producers in which each side of the triangle could not function without the support of the other two.[10]

2.2 From iron triangles to policy networks

In the 1970s the triad of influences on the policy process in the USA was dubbed 'the iron triangle'. Lowi's concept of loose triangular dependencies had hardened into one of inflexible structural policy processes. Peters describes the interaction thus:

> The pressure group needs the agency to deliver services to its members and to provide a friendly point of access to government, while the agency needs the pressure group to mobilize political support for its programs among the affected clientele...[11]

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7 Ibid..

8 J. Leiper Freeman, *The Political Process,* 2nd. edn., Random House, New York, 1965, p. 11.

9 Richardson & Jordan, *Governing under Pressure,* pp.160-161.

10 Jordan, 'Sub-governments, policy communities and networks', p. 325.

11 G. Peters, *American Public Policy,* Macmillan, Basingstoke, 1982, p. 24.

Peters claimed that much of the domestic policy of the USA was formulated within these functionally specific subsystems. Their exclusivity was compounded by the lack of central co-ordination of the processes of formulation and of the ensuing implementation and outcomes. Heclo on the other hand thought that the iron triangles concept was too rigid and static to explain fully the nature of the policy process. Instead he saw policy-making as accompanied by 'clouds of issue networks' and the process as 'conflictual, permeable and predictable'.[12]

Heclo's imagery is of stable interest elements constantly reforming as the policy situation demanded. His impression of the relationships between interest groups, officials and governments as somewhat ephemeral and 'loose-jointed' is echoed by Rokkan and Kvarvik in Norway who found, in separate studies, that interest group participants in the process preferred semi-formal forms of interaction to be incorporated into binding structures. So Rokkan states:

> ...the crucial decisions on economic policy are rarely taken in the parties or in Parliament: the central area is the bargaining table where the government authorities meet directly with trade union leaders, the representatives of the farmers, the smallholders and the fishermen, and the delegates of the Employer's Associations. These yearly rounds of negotiations have in fact come to mean more in the lives of rank and file citizens than formal elections. ...the corporatism of the two-tier system of decision-making is implicit and latent, not formal and institutionalized'.[13]

Rokkan's observations have a grass-roots feel about them that reminds the analyst that interest group participation in policy-making is not confined to remote, macro-level activities of peak organisations and senior public officials. Kvarvik adds to this understanding of micro-level policy-making his finding that many policy participants move in and out of organisations in all sectors on the basis of their expertise either in the process or in the specialised activity which is the subject of the negotiations. Policy making is conducted through a 'network of administrative committees' in a process of 'the secularisation of administration'.[14] This notion of secularisation emphasises the fact that the concept of policy networks is much looser than that of neo-corporatism with its implicit connotations of big business and big unions. The dogma of monopolistic representation gives way to include concepts of a broader-based community involvement.

2.3 Richardson and Jordan's original concept

In the late 1970s Richardson and Jordan perceived that the disjunction between the continuing academic debate about the issue of pluralism in the policy-making process, and the conventional paradigm of the pre-eminence of the electorate, political parties,

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12 H. Heclo, 'Issue Networks and the Executive Establishment', in *The New American Political system,* ed. A. King, American Enterprise Institute, Washington, 1978, pp. 87-124, p. 105.

13 Quoted in Richardson & Jordan, *Governing under Pressure,* p. 164.

14 Ibid., p. 165.

Parliament and Cabinet, was detrimental to comprehensive policy-analysis because many important socio-economic decisions are not even discussed in such fora. They posited the hypothesis that policy-making is fragmented into subsystems which are grouped around substantive issues and ongoing relationships rather than such traditional political structures and processes as party platforms, government departments or plenary sessions of Cabinet. They call these subsystems of political activity 'policy communities'.[15] They describe them thus:

> It is the relationship involved in committees, the *policy community* of departments and groups, the practices of co-option and the consensual style, that perhaps better account for policy outcomes than do examinations of party stances, of manifestoes or of parliamentary influence.[16]

Richardson and Jordan argue that this 'contemporary style of policy-making' has emerged because of the fact that increasing government intervention in a wide range of societal issues requires further intervention to manage the interdependence of problems which results. Government becomes the management of a complex environment through the co-operation of mediating institutions. Policy is therefore the outcome of a process of adjustment based on mutual need to achieve objectives and formulated in a proliferation of institutions and processes designed to negotiate the accommodation of interests.[17] They saw the process, however, as relatively closed:

> The policy-making map is in reality a series of vertical compartments or segments - each segment inhabited by a different set of organised groups and generally impenetrable by 'unrecognised groups' or by the general public.[18]

Such a system of policy-making has both costs and benefits for society-at-large. These are summarised in table 1.1.

Table 1.1: The costs and benefits of policy communities

Costs	Benefits
• the unorganised are undervalued and excluded	• multiple channels exist for influencing policy-making
• group interests dominate therefore policies may not work in wider environment	• conflict avoidance is possible through group participation
• goal displacement and diminished autonomy for groups	• specialised knowledge is available for the solution of policy problems
	• there is increased likelihood of implementation due to participation in policy formulation

Source: Richardson & Jordan, *Governing under Pressure,* pp. 172-180

15 Richardson & Jordan, *Governing under Pressure,* p. 43-44.
16 Ibid., p. 74.
17 Ibid., p. 171-174.
18 Ibid., p. 174.

Richardson and Jordan see the policy community concept as a more adequate explanation for policy formulation, implementation and outcomes than notions of party or parliamentary discourse. They also imply that this is a situation which evolved in the 1970s in Britain and Europe. However, Richardson and Jordan did not fully articulate the characteristics or dynamics of policy communities. Other policy theorists have developed the concept into a more detailed approach to policy analysis.

2.4 Pross's attentive public and policy community

Pross is a Canadian policy analyst who found Heclo's concept of cloudy networks too open, and Peters' concept of iron triangles too closed to explain fully the policy process in a federal system such as Canada's which has no equivalent to the Congressional subcommittee of the USA. However, Pross believed that the concept of policy community could be adapted to fit the political system in Canada. Pross bases his idea of a policy community on the fact that the complexity and time constraints of political society result in 'special publics' which dominate decision-making in fields where they have competence. 'Special publics' are the narrow end of a funnel bringing issues from the general public to the decision-making apparatus of the state.[19] According to Pross the policy community is:

> ...that part of a political system that - by virtue of its functional responsibilities, its vested interests, and its specialized knowledge - acquires a dominant voice in determining government decisions in a specific field of public activity, and is generally permitted by society at large and the public authorities in particular to determine public policy in that field.[20]

Pross sees the policy community consisting of two parts: the subgovernment and the attentive public. The structure and function of the policy community is given in table 1.2.

Policy communities have mobile populations which vary from policy field to policy field and according to the jurisdictional framework, for example according to which level of government has constitutional responsibility for the policy area. Pross considers that the most significant members are not primarily policy initiators. They see the policy community as a defensive bailiwick against wider public input, or against unwelcome interference from other government agencies.[21] Total restructuring of the policy community may occur if the disjunction between policy and public needs becomes too wide to bridge.

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[19] Pross, *Group Politics and Public Policy*, p. 119.
[20] Ibid., p. 98.
[21] Ibid., p. 107.

Table 1.2: Pross's specification of the policy community

SUBGOVERNMENTS	ATTENTIVE PUBLIC
institutionalised groups or agencies with substantial resources and the incentive to commit them to subgovernment work	introduces into the policy community an element of diversity inhibited at the sub-government level by the need to maintain consensus
goal to keep policy-making at the routine or technical level thereby minimising interference	**goal** to evaluate polices and point out deficiencies
functions • communication between officials and group representatives • automatic group inclusion on advisory committees • continual formal and informal access to senior agency officials • participation on long-range enquiries into policy • invitations to comment on draft policy	**functions** • holds conferences and study sessions • write in newspapers, trade magazines and journals • continuous informal policy review articulating policies & programs with changing public needs
core members ministers (F & S) senior officials (F & S) representatives of vital interest groups industry associations **other members** parliamentarians with special interests officers of Privy Council office foreign governments OECD ILO international pressure groups	**core members** issue-peripheral government agencies journalists private institutions specific interests pressure groups academics think tanks

Source: A. Paul. Pross, *Group Politics and Public Policy,* pp.119-126.

Members of the attentive public range from institutionalised groups, government agencies, issue-oriented groups through to interested individuals. They evaluate policies and point out their inadequacies. Geographical and organisational distance from the policy-making centres, and the fact that communication between members usually occurs via the print media and seminars, keeps the greatest influence of this section on long-term policy. Members of the attentive public may once have been members of the subgovernment or they may be individuals or groups who are opposed to current policy and are therefore excluded from the subgovernment.[22]

Subgovernments are usually very small groups of people intimately connected with the core processes of policy formulation and implementation. Such people usually occupy the top positions in their agencies or organisations. In the public sphere this will include federal and state ministers of the portfolios with the greatest responsibility in the field; the senior public servants from these portfolios;

22 Ibid., p. 105.

chairpersons of advisory committees or executive boards of statutory agencies; and from outside government the key spokespersons for interest groups and private organisations in the field.[23]

A useful observation about subgovernments is made by Ripley and Franklin. They see that subgovernments emerge in part from the complexity of 'the national policy agenda' and thereby become a factor in increasing the level of complexity. They also argue that subgovernments tend to be of greatest significance in the least visible areas of policy.[24] The observation is useful in areas where policy concerns professional expertise not easily accessible to politicians. The cognitive and organisational complexity comprising these areas of policy give rise to groups of policy actors who act as 'translators' between significant professional and non-professional actors. They become skilled in the technical language and professional ideology of the policy arena and can use the scarcity of these skills to exclude other actors from decision-making. This understanding is therefore particularly useful in the science policy arena

Pross sees pressure groups as the main vehicles for policy innovation. Pressure groups move in and out of the core groups of both parts of the policy community. This movement is particularly pronounced in the attentive public where individuals and groups move in and out of prominence as their resources, interests and the public agenda change. Issue-oriented groups are least welcome in subgovernment because they disturb the consensus which grows up around issues.[25] Whereas the subgovernment deplores change which will threaten the status-quo of policy-making, and the attentive public is too remote or lacks the influence to effect short-term radical change, pressure groups can accelerate the pace of change and inject new ideas into the policy process.

In distinguishing these three types of actors or groups of actors Pross has refined the notion of policy community by categorising different sets of behaviour and influence and by analysing the dynamics of the processes involved. The question of how policy changes through time and institutional variation is addressed but not fully developed.

2.5 Coleman and Skogstad: policy community and change

Coleman and Skogstad take Pross's notions of the subgovernment and attentive public and build the concept into an approach which is concerned with policy structure, policy behaviour and the way that these processes and policy output and content

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23 Ibid., p. 98.

24 Randall B Ripley & Grace A Franklin, 'The Nature of Policymaking in the United States', in *Current Issues in Public Administration,* ed. Frederick S Lane, St. Martin's Press, New York, 1986, pp. 48-54, p. 53.

25 Ibid., p. 107.

change through time. They also use the idea of policy networks as specialised interaction occurring around specific policy issues.

Coleman and Skogstad say that policy-making occurs within policy communities in which state actors and representatives of organised interests interact to shape public policy in a given sector over time. In their view policy is not the result of the preferences and influences of social forces or pressure groups implemented by state officials with little autonomy, but of a process in which state institutions can critically shape the manner and degree of influence of organised interests. They therefore place much more emphasis than Richardson and Jordan on the degree to which state autonomy influences policy outcomes which can be explained most satisfactorily by close examination of the interaction between state and societal actors.[26]

According to Coleman and Skogstad, in studies of public policy the organisational capacities of both state and societal actors must be assessed because the structural linkages between the actors are crucial to the kind of outcome that emerges. The structural characteristics of sectoral-level organisations, whether these be state agencies or societal actors, constrain the options available to the policy-makers and reinforce particular values and beliefs in the policy process.[27] Past policy decisions also constrain the available options.

They claim that the normative-ideological order which pervades the political system conditions the norms and values of sectoral actors in the policy community. This strengthens the position of actors with 'compatible' values and weakens those with 'incongruent' values. Central agencies may invade agencies with predominantly incongruent values and impose different policies. Macro-structural factors such as federalism also affect the balance of influence. Strong regional organised interests may develop to counter central state domination, whereas strong state capacity at the regional level may fragment national development of organised interests. Global economic and political concerns and situations also affect both state and sectoral capacity or incentive to control policy-making.[28]

Coleman and Skogstad differentiate between policy communities and policy networks. They say that a *policy community* consists of

> ...all actors or potential actors with a direct or indirect interest in a policy area or function who share a common "policy focus" and who, with varying degrees of influence shape policy outcomes over the long run.[29]

Whereas *policy network* is a concept describing: '...the properties that characterise the relationships among the particular set of actors that forms around an issue of importance to the policy community.'[30] Policy networks are therefore the structural

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[26] Coleman & Skogstad, *Policy Communities and Public Policy in Canada*, pp. 312-314.
[27] Ibid., p. 326.
[28] Ibid., p. 315.
[29] Ibid., p. 25.
[30] Ibid., p. 26.

patterns of interaction between state and society for resolving issues of concern to a given policy community. Different types of policy networks may exist within the same policy community. These emerge because different issues will affect the interests of members of the community to varying degrees shaping, in turn, the particular constellation of actors involved in resolving the issue.[31] Table 1.3 gives the characteristics of different types of policy networks.

One of the refinements introduced into the policy community approach by Coleman and Skogstad is the notion of change in the policy process. They acknowledge that the issue has not yet received much attention from policy community theorists. They begin with the same understanding as Pross that the major objective of actors in subgovernments is to maintain stable relationships and avoid abrupt change. They say that the policy process in the postwar period has become more complex, more formalised and less episodic. In this context change always involves an expansion rather than a contraction in the size of the policy community. The attentive public, the subgovernment and organised interests in any policy community change according to:

- changing social conditions;
- changing economic conditions;
- changing political systems;
- changing international political events;
- changing values.[32]

Some types of policy networks are more susceptible to change over time, for example, concertation networks change less and pressure pluralist networks change the most. In the case studies discussed by Coleman and Skogstad study three patterns of change have become apparent:

1. **pressure pluralism > state direction > pressure pluralism**
   In response to sudden unexpected changes governments will impose policies on a sector. The changes are short-lived as politicians and officials foster new groups or repair the old relationships.

2. **concertation > pressure pluralism**
   Former single government/sectoral relationships fragment in the face of ideological shifts widening and strengthening associational systems increase the ability to influence votes.

3. **pressure pluralism > corporatism**
   Conflict among interests prompts governments and the stronger interests to negotiate to change the policy network structure.

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31 Ibid., pp. 15-23.
32 Ibid., pp. 321-326.

Table 1.3: Coleman and Skogstad's classification of policy networks

1. PLURALIST	**2. CLOSED**
• arise in sectors where state authority is fragmented; (dispersed state authority) • organised interests are at low level of development (weak associational system). **change more likely**	• state decision-making capacity concentrated & co-ordinated • usually long-established, often single agency • organisational interests prominent • strong associational system • virtual monopoly relationship between organised interests and public agency **change less likely**
a. pressure pluralism • groups approach the state independently & compete; • state remains autonomous; • groups assume policy advocacy role.	***b. corporatism*** • multilateral consumer/producer groups combine in a highly integrated associational system to negotiate better conditions in the face of economic or social threat and are co-opted by government into policy participation.
c. clientele pluralism • as above but develops so that: • state officials identify with organised interests; and • become dependent on skills, data, and compliance; • organised interests participate in policy process.	***d. concertation*** • state decision-making capacity concentrated & co-ordinated in single agency for the sector; • organisational interests in the entire sector represented by a single association. **change slow and incremental**
parentela pluralism • organised interests dominate; • members occupy positions in governing party; • state authority diffused to regional levels; • likely to arise if there is one political party & only a few major industries.	

3. STATE-DIRECTED
- highly autonomous co-ordinated state agencies;
- sectoral interests with very weak associational system;
- interests play neither an advocacy or participation role
- usually temporary situation until sectoral interests organise;
- or the precipitating crisis disappears;
- or the state ceases to impose policy on weak, wide-ranging sector;

change and innovation considerable

Data Source: William D. Coleman and Grace Skogstad, *Policy Communities and Public Policy in Canada: A Structural Approach,* Copp Clark Pitman Ltd, Toronto, 1990, pp. 27-29

Coleman and Skogstad admit that their discussion of change in policy communities is not yet fully developed but is intended to stimulate further studies on the subject of the causes and dynamics of change in policy communities. Their discussion of the formation of different types of policy networks is especially useful when analysing interaction between actors with distinctly different interests, ideologies and degrees of control and dependence in policy communities. In this thesis their typology of policy networks has been used to analyse changes in the sectors of the science policy community in Australia and to explain change through time in the way in which policy community relationships and interactions are structured.

2.6 Wright's understanding of ideology

Wright explicitly addresses the role of ideology in policy communities and his insights are useful in explaining how conflicts arise and are expressed through the actions of policy actors. In the course of analysing industrial policy in various countries Wright discovered variations among policy formulation and implementation that could not be explained by orthodox theories. He found that in France, with a supposedly strong, *dirigiste* government, policy outcomes could not be determined whereas in West Germany, with a supportive pro-market ideology, outcomes were more predictable.[33]

Wright claims that analysis at the sectoral and sub-sectoral level reveals a variety of policy subsystems. Actors will behave differently in the policy process faced with the particularity of the circumstances in which specific issues and problems arise and have to be handled: that is, there is a difference between prescriptive values and actual behaviour, the norms for which need to be identified. This is manifested as a gap between rhetoric and reality. Wright maintains that rhetoric indicates that general norms such as non-political bureaucracy, sovereignty of parliament or racial equality have been abandoned in favour of particularistic norms. He says:

> Rhetoric is often used to proclaim or reaffirm systemic and subsystemic policy and behavioural norms, or to indicate ways in which the settings of those norms and the behaviour of governmental and non-governmental actors at sectoral and sub-sectoral levels may conflict or contradict with what was expected or intended.
> ...Faced with the *particularity* of an actual policy issue or problem, government (or a part of it) may prefer to act prudently or expediently *and* inconsistently with its *general* policy stance.[34]

Wright's sectoral model of the policy process is useful because he attempts to account for the gap between political rhetoric, policy behaviour and outcomes. The existence of these gaps draws the policy analyst's attention to the fact that policy sectors are not monolithic and that behaviour in the different sectors will vary according to the norms of the dominant ideology of that sector.

Wright's understanding of norms and values however, leads to some confusion. 'Racial equality', which Wright sees as a norm is, in sociological terminology, a *value* towards which *norms* such as the appointment of public servants on the basis of merit and not race, guide behaviour. However, the basic premise, that governments or subgovernments, when faced with different norms and value systems, cannot always enforce policy behaviour in accord with stated ideological norms and values, applies particularly well to the science policy community in which the norms and values of science often conflict with political ideology.[35]

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33 Maurice Wright, Policy Community, Policy Networks and Comparative Industrial Policies, *Policy Studies*, vol. XXXVI, 1988, pp. 593-612, p. 596.

34 Ibid., pp. 601-603.

35 See, for example, Talcott Parsons, 'An Outline of the Social System', in Talcott Parsons *et al., Theories of Society: Foundations of Modern Sociological Theory,* The Free Press, New York, 1951, pp. 30-79, pp. 43-45; and

3. Development of the Policy Community Approach

The policy community approach sees an analytical division between an attentive public which attempts to exert influence on policy-makers, and a subgovernment which advises and decides. There is, however, an as yet unresolved problem with the comprehensiveness of the explanation of political action it affords. The problem is that of the notion of subgovernment in the absence of a category of action labelled 'government'.

Richardson and Jordan speak about the blurring of the boundary between government and pressure groups by the membership of interconnecting organisations which seem to include government departments and 'the Ministry'.[36] Ripley and Franklin, describing the complexity and indivisibility of government/non-government action policy process in the USA, acknowledge that subgovernments: 'do not dominate all policymaking' but do not further explore the characteristics of government action.[37] Wright speaks about the need for caution in using such terms as 'government' or 'the state', saying that there is often conflict between general policy behaviour (rhetoric) and particularistic policy behaviour (actual behaviour), but does not consider the core of government actors who define general policy behaviour.[38] Pross lists federal and state ministers of the portfolios with the greatest responsibility in the field as members of the subgovernment, but does not define the role of the other members of the government, especially those in the executive government.[39] Coleman and Skogstad speak about the actions of central agencies who 'invade agencies with predominantly incongruent values and impose different policies' but they do not specify who decides which normative-ideological order will prevail.[40] In developing an approach which offers a better explanation of policy-making than the traditional institutional approach these authors have neglected to create a category for actors within the central core of government who are connected only at times of crucial resource decision-making to a particular policy community.

3.1 The executive core

In analysing a particular policy using the policy community approach it becomes apparent that the notion of subgovernment does not cover the entire field of action involved. The approach is particularly problematic when discussing the role of such central agency actors as the rest of the Cabinet when certain portfolio policy issues are being discussed; the senior officials of the Department of Prime Minister and Cabinet

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Malcolm Waters & Rodney Crook, *Sociology One,* 2nd edn., Longman Cheshire, Melbourne, 1990, pp. 29-30.

36 Richardson & Jordan, *Governing Under Pressure,* p. 74.

37 Ripley & Franklin, The Nature of Policymaking in the United States, pp. 51-54.

38 Wright, 'Policy Communities, Policy Network and Comparative Industrial Policies', p. 603.

39 Pross, *Group Politics and Public Policy,* p. 121.

40 Coleman & Skogstad, *Policy Communities and Public Policy in Canada,* p.315.

who have no input into certain policy issues; or the Treasurer or Minister of Finance. Consequently it has been necessary to develop the approach to include a 'government' category of officials and politicians who do not make routine or important decisions about particular policies; whose advice is not automatically sought in such issues; but without whose tacit approval action on an issue could not occur.

In this thesis the category of ***executive core*** is used to denote those actors in the central agencies of governments who do not make regular or routine decisions in a particular policy arena but without whose agreement crucial decisions about that policy arena could not be made.

3.2 The international attentive public

The idea of international influence on policy areas is mentioned by several authors in the policy community debate. Pross talks about the influence of foreign governments, international advisory organisations and multinational corporations on policy.[41] Coleman and Skogstad cite changing international political events as one of the major factors affecting policy-making.[42] Atkinson and Coleman stress the need for a multi-level analysis which incorporates the influence of extra-national organisations in policy-making.[43] These authors consider such international actors as part of the attentive public.

For example, national environmental policies are influenced by the activities of such international environmental pressure groups as Greenpeace or Friends of the Earth, and by international agreements on policy. Policies on managing the social problems created by the HIV virus are influenced by information exchanged at international conferences on AIDS. The OECD gathers, analyses and publishes information which is used to develop national economic policies. Individuals representing international organisations, or influential single-nation organisations, often have great influence However, despite the organised nature of their members' activities, and the fact that they participate in science policy-making at the core of national governments, such actors cannot be classified as a subgovernment because their organisations have no sovereign powers or rights.

Therefore the approach used here has been augmented with the category of ***international attentive public*** which can be defined as a network of organisations and individuals which interacts across national boundaries to influence the policy process of individual nations in areas of special interest to its members.

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41 Pross, *Group Politics and Public Policy,* pp. 124-125.
42 Coleman & Skogstad, *Policy Communities and Public Policy in Canada* p. 323.
43 Atkinson & Coleman, 'Policy Networks, Policy Communities and the Problems of Governance', *Governance,* p. 172.

3.3 The superstructural subgovernment

A fifth category of actors has also been added: that of the ***superstructural subgovernment***. These actors oversee policy in complex policy communities divided into sectors of distinctly different forms of relationship, interaction or function. Increasingly in modern government a set of agencies may develop through time to co-ordinate policy formulation, evaluation and implementation across two or more sectors of the policy community.

The amended policy community approach has five categories into which actors in the policy community can be placed. These are summarised in Table 1.4.

Table 1.4: Categories of actors in an amended policy community approach

Executive core	Actors who occupy central positions in key political institutions who are not members of the policy community but without whose implicit or explicit agreement key decisions about policy could not be made. eg., non-portfolio Cabinet ministers, Cabinet officials, ministers and officials of central agencies, Prime Minister.
Superstructural subgovernment	Actors who participate in decision-making in agencies designed to co-ordinate policy across two or more of the sectors of a policy community. Such actors are likely to be members of the sectoral subgovernments of a policy community eg., interdepartmental committees, allocatory agencies, minister's councils.
Subgovernment	The most influential actors in the policy community who are authorised to make both important and routine decisions in the policy arena. eg., ministers at all levels of government; key public officials, members of advisory committees, industry associations, corporate leaders.
Attentive public	Actors who have a special interest in a policy arena, who can influence decision-making in the subgovernment, but who do not participate in the central decision-making processes. eg., academics, members of think tanks, State Premiers, opposition party spokespersons, specialist journalists, pressure groups.
International attentive public	Actors in international or single-nation organisations with interests and information in a policy arena who may be consulted by subgovernments on policy issues or who may be opposed to the policies formulated by the subgovernment. eg., foreign governments, OECD, International Labour Organisation, Greenpeace, UNESCO.

3.4 Policy community and power

Most writers using the policy community approach have not linked their observations directly to explanations of the exercise of power when they describe the ways in which policy actors influence the policy process to produce outcomes which favour the organised interests they represent. Underlying most of the literature are pluralistic notions of voluntarism, consensus and exchange. Richardson and Jordan base the original concept on the notion of competition between groups of organised interests of which government is the most powerful because of its possession of a monopoly of force, greater legitimacy, and the fact that it can: '...manipulate a broader spectrum of interests' than other groups.[44] For Pross power resides in groups with 'functional responsibilities, vested interests and specialised knowledge'.[45] Power for Pross is therefore a function of political authority, resource control and expertise. The dynamic of action is protection of interests and values. Coleman and Skogstad see resource autonomy and the capacity to co-ordinate as vital characteristics of both government and non-government organised interests.[46] The dynamic of policy communities is consensus: '...a shared set of values, norms and beliefs which shape the policy networks that emerge'.[47] Rhodes does address the issue of the exercise of power when he considers policy communities as part of power-dependence relationships in societies. He talks about power being exercised when influence, as a commodity, is exchanged according to 'rules of the game', for resources.[48] The problem here is that rules of the game are accepted as a given. The interaction which decides the rules of the game is not analysed. Atkinson and Coleman state that the two key questions of policy analysis have become: 'who participates and who wields power.' They add:

> We are told that networks consist of exchange relationships, but what is the structural context in which these exchanges take place? Are there relationships of power and dependency that transcend and color individual transactions.?[49]

They conclude that it is necessary not only to consider questions of integration and consensus, but also to examine the structural effects of dominant ideologies on the way in which policy communities develop. Accordingly, this study goes beyond previous studies by explicitly examining the way in which power is exercised in the policy community through control over the rules patterning interaction, the resources allocated to the production of scientific knowledge, and the ideas about the way in which such knowledge is created and applied. In this thesis the policy community approach is complemented by the use of concepts developed by political sociologists to explain the exercise of power in societies.

3.5 Power

Power is an essential dimension of social interaction. For over a century political philosophers and sociologists have engaged in ongoing debate about the nature of power. The result is a smorgasbord of concepts from which the policy analyst can choose ideas which explain the way in which organisations and individuals maximise their interests in society.[50] To complement the policy community approach it is

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44 Richardson & Jordan, *Governing under Pressure,* p. 14.

45 Pross, *Group Politics and Public Policy,* pp. 119 & 125.

46 Coleman & Skogstad, *Policy Communities and Public Policy in Canada,* pp. 15-23.

47 Ibid., pp. 29-30.

48 Rhodes, *Power Dependency, Policy Communities and Intergovernmental Networks,* p. 3.

49 Atkinson, & Coleman, 'Policy Networks, Policy Communities and the Problems of Governance', p.161.

50 Malcolm Waters, *Modern Sociological Theory,* Sage Publications, London, 1994, forthcoming.

necessary to use a concept of power which explains the strategic actions of individuals or organisations which seek to dominate action in a particular policy arena in order to further their interests.

3.5.a Structure and agency

Since the 1970s the most fruitful debate on power has been that between agency and structure: between behaviourist explanations involving concepts of the individual exercise of will; and structuralist explanations that power is a function of the organisation of social action. The behaviourist argument is encapsulated in Weber's classic definition of power:

> The probability that one actor within a social relationship will be able to carry out his own will despite resistance, regardless of the basis on which the probability rests.[51]

From this statement about interaction Weber constructed his model of social behaviour built on the premise that actors (individuals or organisations), through the exercise of coercion or domination through different types of authority, can force other actors to act against their own interests.

This description of the exercise of power in the simplest form of social interaction is elaborated by Dahl in his study of the exercise of influence in key issues of public policy-making in New Haven, Connecticut.[52] Dahl's observations lead him to develop a pluralistic approach to the exercise of power in which power is divided between different actors or groups. His definition that: 'A has power over B to the extent that he can get B to do something B would not otherwise do.' is a paraphrase of Weber and is based on the belief that B's behaviour is caused by A's behaviour. It does not take into account the fact that B may behave in the way that A prefers without A having to act at all. That is, it does not take into account the structural conditions in which action occurs.

This point is taken up by Bachrach and Baratz who argue that there are two facets to the exercise of power: behaviour which causes others to respond by behaving against their own interests; and behaviour that operates both to limit the other's access to decision-making which would go against the actor's interests, and to reduce the probability that discussion of those interests would arise in the first place.[53] This explanation focuses for the first time on 'non-decision-making' as an aspect of power which is particularly relevant to public policy-making. The capacity to ignore or 'hide' issues is as important as the capacity to win debates over decision-making.

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51 Max Weber, *From Max Weber: Essays in Sociology,* eds. & transls. H.H. Gerth & C. Wright Mills, Routledge & Kegan Paul, London, 1948, p. 53.

52 Robert A. Dahl, *Who Governs?,* Yale University Press, New Haven, 1961.

53 P. Bachrach & M. Baratz, 'Two Faces of Power', *American Political Science Review,* vol. 56, 1962, pp. 947-1052.
'Decision and Nondecisions', *American Political Science Review,* vol. 57, 1963, pp. 941-1051.

Richardson and Jordan refer to Bachrach and Baratz' studies when they discuss the issue of agenda-setting in policy communities.[54] However, the approach still assumes that actors behave in relation to subjectively-defined wants and needs rather than to structurally defined interests.

The 'structuralist' approach to power originates with Marx who explained social power as a function of the way in which society is structured to maintain the distribution of economic resources in favour of those who control the means of production.[55] Writers on power who adopted Marx's approach see power as inherent in the way in which social, political and economic institutions are developed. They explain behaviour in terms, not of individual or group will, but as being in conformity with such institutions as factory production, social class, and access to education. Lukes is such a writer who criticises the behaviourist approach to power, as articulated by Dahl, and Bachrach and Baratz, on the grounds that their explanation fails to see that the exercise of power in society has a third dimension which is invisible to those who assume that all behaviour is subjectively defined.

Lukes claims that power can be exercised in such a way as to deny actor B awareness of the fact that his/her interests can be achieved by acting in a different way to the action proposed by actor A. This is achieved through the manipulation of social structures in such as way as to 'distort' the awareness of actor B that their interests are different, and that there are ways of behaving which will change their capacity to achieve those interests.[56] This explanation of power alerts the policy analyst to the way in which ideology can affect actors' perceptions of public policy issues. It is important too because it highlights the agency/structure dichotomy which underlies many political ideologies which are used to justify the distribution of societal resources in particular ways. Theories of individual choice use behaviourist explanations of individual will and capacity to decide courses of action. Theories of social justice argue that certain individuals and groups are structurally disadvantaged and need publicly-provided assistance to overcome these disadvantages.

However, Lukes' three-dimensional approach is of limited use in explaining social change. If individuals are prevented from recognising their own interests the question arises of how these are to be defined since another agency must always be involved in correcting structural distortions of perceived interests. Behavioural explanations diminish the impact of social structure whilst structural explanations deny the possibility of change through individual action. The political sociologist Giddens tries to resolve the dichotomy and he provides a useful explanation of power in his concept of structuration.

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54 Richardson and Jordan, *Governing under Pressure,* p. 80.
55 Bob Jessop, *The Capitalist State,* New York University Press, New York, 1982, pp. 9-20.
56 Steven Lukes, *Power: A Radical View,* Macmillan, London, 1974, pp. 24-25.

3.5.b Rules, resources and ideas

Giddens analyses the way in which individual actions accrue over space and time to form social structures which are recognisable because they are reproduced. Interests and power relationships are inherent in such actions. For Giddens every individual social action both emerges from, and is generative of the pattern of human existence which can be thought of as a social system:

> ... the structural properties of social systems are both the media and the outcome of the practices that constitute those systems.... every process of action is a production of something new, a fresh act; but at the same time all action exists in continuity with the past, which supplies the meaning of its initiation.[57]

The conditions of autonomy and dependence experienced by actors in the social system are also reproduced in interaction:

> *Power* is an integral element of all social life as are meaning and norms; this is the significance of the claim that structure can be analysed as *rules* and *resources*, resources being drawn upon in the constitution of power relations. All social interaction involves the use of power, as a necessary implication of the logical connection between human action and *transformative capacity.* Power within social systems can be analysed as relations of autonomy and dependence between actors in which these actors draw upon and reproduce structural properties of *domination*..[58]

'Transformative capacity', which can be thought of as the capacity to change objects, symbols, ideas and the structural conditions of action, is expressed in interaction through the control and use of resources. According to Giddens the exercise of power in society is therefore inherent in the capacity of actors to influence the outcomes of action in such a way as to satisfy their wants; and for Giddens only people have wants: social systems do not.[59]

The concepts of wants, interests, ideology and power are linked for Giddens through the significance of action. The fundamental basis of interests are 'wants'. These are achieved through a given course of action, the outcome of which can be influenced by the use of resources. Interest groups are therefore collectivities of people with common wants and ideas about their realisation. Those groups or individuals who control a majority of resources have the power to influence courses of action in ways that will result in favourable outcomes for the individuals in that group.

Giddens perceives ideology emerging when groups with sectional interests seek to conceal the fact that most action in society serves their interests, since such a realisation would cause social disintegration at the level of individual action. Concealment is achieved through the manipulation of resources in three ways. Firstly,

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57 Giddens, *Central Problems in Social* Theory, pp. 69-70.

58 Anthony Giddens, *A Contemporary Critique of Historical Materialism,* Macmillan, London, 1981, pp. 28-29.

59 Ibid., p. 189.

to represent sectional interests as universal ones: secondly, the denial of contradictions which arise out of the fact that dominant interests are being served (for example, to label conflict which arises out of economic production as 'non-political'), and thirdly, by portraying as 'natural' conditions and actions which preserve the status quo.[60]

Clegg also sees power defined in terms of agencies and events occurring in a framework of systematic relationships, but he criticises Giddens for underestimating the effect of structural constraints upon the capacity of actors to structure relationships according to their wants.[61] In Clegg's explanation of power he employs the notion of 'power circuits' which are sets of structured relationships through which different types of power flow. There is no simple definition of power for Clegg. He maintains that power is multi-faceted and that any explanation of the exercise of power in social action needs to be as complex as the phenomenon it is attempting to explain.[62] There is power which is manifest in the rules and domination which cause action in agencies leading to certain outcomes. He says:

> Power, viewed episodically, may move through circuits in which rules, relations and resources that are constitutive of power are translated, fixed and reproduced/transformed.[63]

In Clegg's explanation this episodic power is 'power over' the agency of others which allows the dominant agency to achieve outcomes favourable to its interests. There is an interdependence of rules, resources and ideas and the capacity to use any of these to control outcomes. In Clegg's words:

> Existing social relations constitute the identities of agencies, whether individuals or some collective loci of decision-making and action. Agencies' causal powers will be realized through the organization of standing conditions. These require that agencies involved in what Hindess terms 'arenas of struggle' are capable of utilizing means in order to control resources which have consequential outcomes for the scope of action of these agents. Each agency is operative in a highly complex environment of standing conditions. Each is among many others with strategic interests in each other and in the relations that constitute them as actors in the same system. Agencies possess varying control of resources which they have various means of effectively utilizing in order to produce consequential outcomes for their own and others' agency.[64]

For Clegg, control over rules is the capacity to authorise or veto action.[65] Change occurs through conflict over the issues of the rules of action, the membership of agencies and the techniques of production and discipline. These techniques are both the means of innovation in action and production and the 'bearers of domination'. New techniques challenge existing power relationships and set up resistant action by

60 Ibid., pp. 188-195.
61 Clegg, *Frameworks of Power,* p. 147.
62 Ibid., pp. 211-218.
63 Ibid., p. 211.
64 Ibid., p. 215.
65 Ibid., p. 209.

those whose interests are threatened. Dominant interests will therefore try to control not only resources, but also the ideas which inform the social relations which legitimate the rules of action which structure the relations of production and meaning.

Clegg's explanation of power is useful in alerting the policy analyst to the inherent complexity of power relationships in any social system of action. Individuals act in agencies and environments which are complex sets of interdependent relationships of resource exchange, rule-making and structures of meaning. Mechanisms of accountability, co-ordination and control reinforce dominant interests. Agencies requiring resources therefore have to abide by rules set by what Clegg terms 'nodally positioned agencies in the environment'.

Through Clegg's extension of the structural understanding of power, the policy process and its outcomes can therefore be understood by tracing the control of resources, rules and ideas between agencies through time. The concept of power as inherent in the control of the rules of action, the ideas which underlie the structures and relationships which both emerge from and generate the rules; and the resources necessary for interaction and production, can be integrated into the policy community approach so that, in any particular policy arena, it is possible to explain change through time by analysing the way in which significant actors in the subgovernment, influenced by ideas and interest groups in the attentive public and the international attentive public, will both make decisions about the allocation of resources; influence members of the executive core to endorse those decisions; and seek to control ideas and rules in order to maintain their interests and their status as 'nodally placed' actors.

Action in policy communities can be therefore be interpreted as being oriented around the control of rules, resources and ideas to protect or promote interests. But, as Wright, Pross, and Coleman and Skogstad point out, not all action is informed or guided by the same set of values, norms and ideologies. Giddens argues that the use of ideology as a justification for action enables actors to disguise the fact that they are influencing the control of resources in order to further their own interests. Action in the science policy community is distinctive because it involves both political ideology (discussed in chapter 2) and a unique set of values and norms which serve to protect the interests of scientists. These scientific norms and values are conceived by many writers to be a distinct social system of action.

4. THE SYSTEM OF SCIENCE

The production of scientific knowledge in a society can be seen analytically as a separate subsystem of society because action in the scientific community is patterned by unique norms and values. These norms and values affect the way in which scientists interact with governments and some understanding of them is therefore necessary in order to explain interaction in the science policy community.

4.1 Merton on the norms of science

Merton was one of the first modern sociologists to analyse the relationship between science and society. He saw the relationship as one of 'dynamic interdependence' between science as an ongoing social activity and the 'environing social structure'.[66] Merton's fundamental observation is that it is the method of producing scientific knowledge which distinguishes scientific activity from other social activity:

> The ethos of science involves the functionally necessary demand that theories or generalizations be evaluated in terms of their logical consistency and consonance with facts.[67]

According to Merton the production of scientific knowledge has to remain separate from other social activity because the rigorous observations upon which the scientific method is based has to be free from possible political or religious bias. If the knowledge produced by scientists as a result of testing hypotheses through observations, or using observations to develop testable hypotheses, was in conflict with dominant political or religious ideologies about the way the world should be, then the scientific method would be at risk.

Merton distinguished four norms which he saw as constituting the 'ethos of science' and which guided the actions of its practitioners in such a way as to avoid distortions of the scientific method by values dysfunctional to the use of the scientific method. The norms are:

1) **Universalism**
All natural phenomena are open to investigation. Scientific principles are not related to national boundaries. Knowledge that has been established by scientific methods in one country is equally as valid in any other country, and its validity does not change with nationality, race or religion.

2) **Communalism**
Scientific knowledge is not considered to be the private property of the scientist who produced it but part of the body of scientific knowledge open to all scientists. '...recognition and esteem are the sole property right of the scientist in his discoveries.' Since the status of scientists within the science system is dependent upon evaluation of their contribution to knowledge this norm encourages the sharing of knowledge.

3) **Disinterestedness**
This norm states that scientists ideally should not profit in any way other than scientific status from the discoveries they make. Scientific work should be carried out in order to add to the body of knowledge and not to gain power, social status or money. The norm functions to preserve the 'reputability' of scientific knowledge that is not defiled by the possibility of personal gain.

4) **Organised scepticism**
Each scientist is responsible for the validity of the methods used to verify the work of other scientists. Knowledge is not accepted as truth until it has been proven to be not false by 'detached scrutiny'. The norm needs to be followed

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66 Merton, 'Science and the Social Order', p. 585.
67 Ibid., p. 595.

> most rigorously when the scientific method is applied to areas of knowledge formally considered sacred or which would affect the distribution of power in society.[68]

These idealised norms of science are used by the scientific community to counter threats to the autonomy of their system from the wider community. In 1937 Merton observed the threat to scientific communities in Germany and Russia from totalitarian governments. This led him to analyse the special requirements of the scientific community. Merton writes:

> The exaltation of pure science is thus seen to be a defence against the invasion of norms which limit directions of potential advance and threaten the stability and continuance of scientific research as a social activity.
> Conflict becomes accentuated whenever science extends its research to new areas towards which there are institutionalized attitudes or whenever other institutions extend their area of control.[69]

Merton's analysis of science as social activity is important to the analysis of science policy because of the insight he lends to the interaction between the scientific community and governments. Conflict is implicit in the relationship because the ethos of science separates the scientist from other social norms and values, particularly from political interests.

4.3 Storer on science as a social system

Storer further developed Merton's concepts by adding the notions of patterned scientific interaction oriented to the exchange of a particular commodity. He sees the science system as:

> ...a stable set of patterns of interaction, organized about the exchange of a qualitatively unique commodity and guided by a shared set of norms that facilitate the continuing circulation of that commodity.[70]

4.3.a Patterns of interaction

Storer sees science as a 'non-service' profession which, although it differs from professions such as medicine or law in that scientists do not provide a direct service to the public, nevertheless exhibits characteristics typical of professions in general. These are the production, maintenance and transmission of a specialised body of knowledge, the autonomous recruitment training and control of its members, a reward system which both motivates members and is a means of control, and the regulation of the relations between members and non-members.[71]

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68 Merton, 'Science and Democratic Social Structure', p. 606-615.
69 Merton, 'Science and the Social Order', p. 597; &
'Science and Democratic Social Structure', p. 615.
70 Storer, *The Social System of Science*, p. 91.
71 Ibid., p. 75.

The central core of scientists engaged in basic research, teaching and the evaluation of the work of other scientists, forms the reference group for the larger body of scientists whose work is the application of scientific knowledge to the solution of practical problems. Storer maintains that the norms and values of this central core provide the ideal standard for the patterns of interaction of the total community of scientists in a society, and the uniqueness of this normative structure is the basis of his claim that science is a distinct social system.[72]

4.3.b The exchange commodity of competent response

This competent response of scientists towards the work of other scientists is seen by Storer as the commodity (comparable to goods and services) which serves as a reward within the science system.[73] Storer maintains that the norms and value of science are directed to the goal of creating knowledge:

> The desire to extend our understanding of the workings of the universe ... is the baseline against which other motives must be compared....
> So long as the interaction among scientists places a premium upon creativity, we may assume that they tend - while in the role of scientist - to accept this as their major professional goal. The importance of creativity is, in effect, built into their universe of discourse; in order even to converse as a scientist, one must implicitly accept this goal.[74]

The norms of science, therefore, impel the scientist not only to create through the discovery of new concepts about the universe, but also to share that knowledge so that it may be evaluated against previously accepted knowledge and legitimised in the science system. This evaluation cannot be carried out by 'lay' persons because they do not have the knowledge or awareness of the systematic processes of scientific evaluation to judge what is competent scientific work. The process of evaluation is only valid for scientists when it is performed by persons sufficiently socialised in the methodology, norms and values of science to provide a response which has meaning in the science system. The idealised norms of science are not imposed from the wider society upon the science system, but emerge from the desire of scientists to obtain competent response from their colleagues. Scientists' behaviour can be explained by the degree to which these ideal norms fit the world in which the scientist actually works. Lack of fit results in behaviour which protects the norms.[75]

Storer argues that the social structure of science (that is the working out of the system in the 'real' world) emerges as a compromise between the norms of science and environmental constraints. He does so by examining the way in which the norms become distorted in the everyday world of the scientist. Thus the norm of disinterestedness is distorted when some scientists deliberately choose research topics

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72 Ibid., pp. 14-15.
73 Ibid., pp. 69-74.
74 Ibid., p. 58.
75 Ibid., pp. 100-101.

that will further their career, social status or income.[76] The norm of organised scepticism which serves to discourage fraud and incompetence is compromised by the expense of replicating experiments, the need for applied scientists to produce commercially applicable results in a short time and the sheer volume of new knowledge in any one field that peers must evaluate in order to assess the validity of new work.[77]

Perhaps the norm which has been the most difficult to uphold is the norm of communality. Merton states in his original paper on the norms of science:

> Property rights in science are whittled down to a bare minimum by the rationale of the scientific ethic....The institution of science as part of the public domain is linked with the imperative for communication of findings. Secrecy is the antithesis of this norm; full and open communication its enactment.[78]

Violation of the norm rests on the understanding that 'knowledge is power'. Sponsors of the production of scientific knowledge who wish to maintain their superiority vis à vis rivals will expect researchers in their employ to forgo their rights as scientists to share their results with the rest of the scientific community.[79] In terms of science policy, secrecy in science becomes a problem for governments when publicly-funded science is appropriated by scientists working in the private sector; or obversely, when governments wish to commercialise publicly-funded science and scientists argue that all science should be considered as a public good.

The concepts outlined above will be used in the thesis to explain interaction between political and scientific actors in the science policy community. Political action is centred around the allocation of public resources. Scientific action is centred around the creation of new scientific knowledge. Both sets of actors use control over rules, resources and ideas to shape policy outcomes which further their particular interests. Scientists and political actors justify their actions in terms of differing ideologies. Chapter two will discuss the way in which the ideology of science and political ideologies interact within changing social, political and institutional contexts.

6. CONCLUSION

This chapter has been concerned with examining concepts from different social science disciplines which can inform the analysis of science policy, particularly those factors which effect and affect change, both in the policy process and in policy outcomes. The following statements about science policy underlie this analysis of changing science policy in Australia from 1965 to 1990.

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76 Storer, p.110.
77 Ibid., p. 118-121.
78 Merton, 'Science and Democratic Social Structure', p. 611.
79 Storer, *The Social System of Science*, p. 126.

6.1 Definition: decisions, actors and power

Science policy is defined as a set of interrelated decisions taken by a political actor or group of actors concerning the selection of goals and the means of achieving them within the science policy arena in which governments and scientists interact to provide the rules, resources and ideas for the production of scientific knowledge. These decisions should, in principle, be within the power of these actors to achieve.

6.2 Decision-making: expertise and authority

The science policy community is that part of a political system that - by virtue of its functional responsibilities, its vested interests, and its specialised knowledge - acquires a dominant voice in determining government decisions in the field of government activity related to the allocation of societal resources to the production of scientific knowledge and regulation of the uses to which that knowledge is put; and is generally permitted by society at large, and the public authorities in particular to determine public policy in that field.

6.3 Power: control over rules, resources and ideas

Power in the science policy community is exercised by significant actors who enjoy varying degrees of autonomy and authority in policy-making. Power in the networks which structure the policy community is a function of the resources, rules and ideas that actors can mobilise to influence the course and outcomes of interaction. These rules, resources and ideas, and the capacity to mobilise them, are the products of the structure of organised interests which may be dominated by one or more agencies. The policy process and its outcomes can therefore be fully understood only by tracing the interaction of resources, rules and ideas between agencies through time.

6.4 Interaction: norms and values

Science policy is formulated, implemented and evaluated by actors in organisations both governmental and non-governmental, scientific and non-scientific, acting according to the norms and values of the most powerful organised interests within the science policy community, within policy networks of structured or informal relationships forming associational systems of varying degrees of cohesion.

6.5 Dynamic of action: the exchange process

The dynamic underlying the relationship between governments and the scientific community is that of the exchange of resources. Governments need scientific knowledge to organise and manage the complexities of modern society and to stimulate economic, social and cultural development. The scientific community needs economic and ethical support from governments to finance and legitimate the production of scientific knowledge.

6.6 Pressure groups: the agents of change

Pressure groups are atomistic, self-organised groups, whose members share common interests in science policy and ideas about how those interests should be realised. Groups evolve in response to changes which threaten their interests. They often interact in one-to-one relationships with government, or governmental agencies. Those groups which control the resources which are at any given time salient in a particular area of science policy have the power to influence negotiating processes and courses of action in such a way as to result in outcomes favourable to their interests. Pressure groups are therefore likely to be active in the policy community on an ad hoc basis as their resources and the threats to their interests fluctuate.

6.7 Conflict: different values and threatened interests

Conflict arises in the policy community when the interests of the scientific community, based on its particular norms and values, do not accord with the interests of the dominant political ideology based on a different set of norms and values, or when the dominant organised interests are threatened by innovative techniques or ideas.

CHAPTER 2

THE IDEOLOGICAL, INSTITUTIONAL AND ECONOMIC CONTEXT

Action in the science policy community in Australia takes place in a complex set of public, private and semi-autonomous organisations. An analysis of science policy therefore needs an understanding of the rules, ideas and resources underlying the establishment and operation of, and interaction among, scientific and political institutions. These rules, resources and ideas are the basis for action and for the emergence of significant actors with interests. This chapter will describe the institutional context of science policy in Australia using the concepts elucidated in chapter one. Australian political ideology in general is discussed briefly, with a fuller exposition of changing patterns of political ideology for science in Australia. The institutions and patterns of action of the science system are described in order to appreciate their unique development in Australia. The resources available for the production of scientific knowledge come from the economy: both directly in the form of financial resources, and indirectly in the form of skilled human resources. The chapter ends with a discussion of the composition and global context of the Australian economy in terms of the implications for science policy of particular patterns and indicators of activity.

1. AUSTRALIAN POLITICAL IDEOLOGY

In chapter one the ideology underlying action in the science system was discussed using Merton's concept of the ethos of science and Storer's concept of competent response. The following brief discussion of political ideology in Australia is included to provide a basic understanding of the relationship between political ideology and action in the political system in Australia. The most significant ideologies in the relationship between the political system and the science system in Australia are utilitarianism, populism and socialism. However, these three ideologies cannot explain all aspects of the relationship at the end of the twentieth century and three further terms have been coined by the author to explain how governments perceive the relationship between the state and science.

1.1 Political ideology and science policy

Ideological labels are often a poor guide to political behaviour in Australia. During periods of political change in the twentieth century political parties have shuffled ideologies to find the one which seems most likely to appeal to the critical interest groups of the time. Loveday claims that in Australia: 'Governmental actions can almost always be explained with no more than incidental reference to political ideas'.[1] The terms 'socialist', 'liberal' and 'conservative' could be applied to rural farming interests, mining magnates and environmentalists respectively.[2] Menzies himself said in the 1960s:

> Where government action or control has seemed to us to be the best answer to a practical problem, we have adopted that answer at the risk of being called Socialists.[3]

In the case of the allocation of resources to the production of scientific knowledge this may mean that the Hawke government of the 1980s pursues a policy of the privatisation of Australian science, whereas the Bruce government of the late 1920s, which took a conservative stance on the provision of public goods, presided over the expansion of the Council for Scientific and Industrial Research (CSIR) which set the pattern of government-funded science in Australia for the next fifty years. The way in which political ideology affects the production of scientific knowledge cannot be categorised according to 'right' or 'left' labels of declared political intent.

In Australia there have been four basic ideologies about the relationship between governments and the production and application of scientific knowledge: colonialism; nationalism; conservatism and techno-economism. In the second half of the twentieth century conservatism and techno-economism predominate but elements of colonialism and nationalism persist. A fifth ideology, environmentalism, has become electorally salient in the 1980s.

1.1.a Colonialism

For the first 180 years of white settlement in Australia the power of British institutions and British capital was significant in the development of the Australian political system, Australian culture and the Australian economy. Opposition to that power began in the 1840s with the move towards self-governed colonies but it was not until the 1890s that left-wing populism mobilised politically against rural and mercantile interests. The elimination of British colonial exploitation was the primary objective of the labour movement in Australia at the end of the nineteenth century.[4] Brugger and Jaensch argue that understanding 'the British economic connection' is crucial to understanding the political ideologies of Australia in the first

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1 Peter Loveday, 'Australian Political Thought', in *The Pieces of Politics,* 2nd edn., ed. R. Lucy, Macmillan, Melbourne, 1979, pp. 2-28, p. 4.

2 In 1961 Encel, writing for the American journal *Science,* explained how the Australian tradition of intervention in the name of 'national development', even by conservative governments, would be considered 'socialistic' in the USA.
Sol Encel, 'Financing Scientific Research in Australia', *Science,* vol. 134, no. 3474, 28 July 1961, pp. 260-266, p. 265.

3 Loveday, 'Australian Political Thought', p. 2.

4 Bill Brugger & Dean Jaensch, *Australian Politics: Theory and Practice,* Allen & Uniwin, Sydney, 1985, pp. 12-13.

three decades of the twentieth century.[5] The fact that there was no rebellious cutting of the colonial ties with Britain ensured that colonialism was an important in the politics and economics of Australia until the retirement of Menzies in 1966.[6]

Colonialism decided the shape of Australian scientific institutions. In the early nineteenth century Australian science was moulded in the British tradition. The early scientists were British scientists, the early institutions were modelled on British institutions and the knowledge they created was dispatched to Britain for peer evaluation and legitimation. This is to be expected in a colony which was huge, sparsely populated, culturally remote from the indigenous and regional populations, and economically dependent on its mother country. The effect upon the institutions of science in Australia was to engender a sense of intellectual dependence on the British model of the production of scientific knowledge which did not begin to diminish until the 1930s.[7]

Examples of the colonial bias in the establishment and organisation of scientific institutions abound. CSIR was established in 1926 partly in order to attract funds from the Empire Marketing Board set up in Britain to foster scientific research in the colonies which would be of economic benefit to Britain.[8] Sir David Rivett, the Chief Executive of CSIR for its first twenty-four years, was an ardent supporter of Britain, even to the extent of compromising his belief that the production of scientific knowledge in Australia should be autonomous of any political influence. In keeping with his desire to further economic interdependence in the Empire, he agreed that wool research in Australia should be subordinate to that conducted in Britain.[9] Until 1938 there was no science journal in Australia. The editorial of its first issue includes a qualification of its existence:

> There is much to be said for reducing rather than increasing the number of scientific journals in *the Empire*: to add one more to the list can be justified only if there is a place to be filled, and the capacity to fill it.[10] [emphasis added]

The use of the word 'Empire' rather than 'world' emphasises the colonial parameters of thinking in scientific institutions in Australia immediately prior to the Second World War. The overemphasis on rural research in CSIR can be attributed to the

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5 Ibid., p. 30.

6 Graham Maddox, *Australian Democracy in Theory and Practice,* Longman Cheshire, Melbourne, 1991, pp. 147 & 301.

7 Moyal estimates that Australian science did not reach the stage of independence and self-reliance that characterises Basalla's final stage of the diffusion of western science until 'the third decade of the twentieth century'.
Ann Moyal 'The Effect of Institutional Evolution on Science Policy', in *Science and Technology for What Purpose?: An Australian Perspective*, ed. A.T.A. Healy, Australian Academy of Science, 1979, pp. 67-83, p. 68.

8 C.B. Schedvin, 'The Culture of CSIRO', *Australian Cultural History,* no. 2, 1982-83, pp. 76-89, p. 78.

9 Ibid., p. 81.

10 Anon. 'A New Venture', *The Australian Journal of Science,* vol. 1, no. 1, 1938, p. 1.

British desire to protect British secondary industry markets. It was not until the chief of BHP, Essington Lewis, visited Japan in 1936 and realised the implications of that country's arms build-up that the development of secondary industry was encouraged by the establishment of the National Standards Laboratory.[11] It is perhaps ironic that the next phase of colonialism may be Japanese-funded. The proposed multi-function polis is based on the same interaction of economic exploitation and the production of scientific knowledge that underlay CSIR.[12]

1.1.b Nationalism

Nationalism has also been influential in the relationship between the Australian scientific community and governments. Nationalism is an ideology which glorifies the perceived shared characteristics of individual states, territories, citizens and cultures. Nationalistic sentiments often arise in the face of a challenge to national sovereignty and economic independence, or as a protest against colonial domination. In Australia nationalism developed after 1901 as a unifying counterpoint to the conflict inherent in a federation.[13] Nationalistic ideas were used by Hughes to retain political power until the end of the First World War.[14] Nationalism was similarly invoked as a mechanism of unification by both the Whitlam government and the Country Party in 1973.[15]

Nationalism has both positive and negative effects on scientific activity. In 1964 Sir Frederick White, Chairman of CSIRO, said: 'Military objectives and national prestige are the predominating motives of the Western world'.[16] Nationalistic sentiment can give rise to the establishment of research institutions and facilities which are symbols of a nation's cultural and economic maturity. The possession of such facilities renews the citizen's commitment to the nation by stimulating pride in belonging to a nation powerful enough to provide them. The negative effects arise from the sense of exclusion which nationalism can engender. The ideas of 'natural' racial inequality are extended to knowledge and the producers of knowledge, so that 'foreign' scientific knowledge and scientists are considered as inferior. In the twentieth century scientific knowledge has sometimes been generated to feed ideological beliefs centred on nationalism. The Nazi experiments on racial superiority and the belief in the genetic ideas of Lysenko in the USSR are

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11 E.A. Boehm, *Twentieth Century Economic Development in Australia,* 2nd edn., Longman Cheshire, Melbourne, 1979, p. 66.

12 Mandeville sees the multi-function polis idea as created by the Japanese Ministry for International Trade and Industry (MITI) and traces its genesis to the need for Japan's economy to use high technology information produced by Pacific Rim nations with sophisticated knowledge-producing systems. T.D. Mandeville, 'A 'Multi-Function Polis' for Australia', *Prometheus,* vol. 6, no. 1, June 1988, pp. 94-106, p. 102.

13 Maddox, *Australian Democracy in Theory and Practice,* p. 158.

14 Brugger & Jaensch, *Australian Politics: Theory and Practice,* p. 29.

15 Maddox, *Australian Democracy in Theory and Practice,* pp. 279 & 293.

16 Sir Frederick White, 'The Strategy of Australian Science', *Australian Journal of Science,* vol.. 26, no. 7, January 1964, pp. 191-195, p. 191.

two instances of the way in which nationalism can override the universalistic norms of science.

Examples of nationalism influencing the production of scientific knowledge in Australia include Hughes' decision after Gallipoli to establish a national science organisation; Menzies' sponsorship of the Australian National University and the Australian Academy of Science; and Whitlam's attack on the effects of multinational ownership of Australian firms on research and development investment. The negative effects of nationalism have been felt when politicians have invoked xenophobic sentiments about foreign science to gain electoral support. The most notorious incident was the 'Red Scientists' scare fuelled by the Menzies government in 1947. A milder form of nationalism was recently invoked by a Liberal Party politician. In an address to the 'Science and Society' conference in June 1989, Warwick Smith, the former Opposition spokesperson on science, said:

> One can argue that science has frequently sailed away from society's needs. It has been carried out for world society needs, not necessarily Australia's needs. There is sometimes a lack of commitment to Australia's development on the part of scientists - and others - in the community.[17]

1.1.c Conservatism

If nationalism attempts to insulate scientific knowledge within national boundaries, or at least direct its effects to benefit the nation, conservatism seeks to restrict decision-making between the scientific community and government to the significant actors in each system, and to restrict the establishment of new political agencies to negotiate the formulation implementation and evaluation of science policy. One of the principle tenets of conservatism is the Burkean belief that leadership arises in societies as a process of societal evolution. These elites are naturally better endowed than the masses to plan and administer society, and once recognised, should be given autonomy to pursue their ideals. Governments should be strong, to maintain law and order, but non-interventionist since all social change should be spontaneous rather than planned. Modern conservatism advocates that social change should occur in response to market forces which should be seen as the natural wellspring of social development. By contrast, radical, government-induced change is inherently misguided because it threatens the social cohesion maintained by traditional values.[18] It is this facet of conservatism which has been so influential in Australian politics and which has, according to Altman, led to the situation in

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17 Warwick Smith, 'Science should be subsumed to society's needs', Address given to the Public Affairs Conference, 'Science and Society', Australian National University, June 7-9 1989.

18 Maddox, *Australian Democracy in Theory and Practice,* pp. 325-328.

which : '...Australia is cursed with extremely conservative ideological establishments'.[19]

The effect of conservatism on the institutions of science in Australia can be seen in the attitudes of particular prime ministers. The institutions and practices introduced by them illustrate their conservative ideology. Bruce expressed the ideology perfectly when he spoke of the establishment of CSIR, stressing the desirability of maintaining the institutional status quo:

> The purpose of the government is, not to create a great new centralized institute of research, but, for the benefit of both the primary and secondary industries, to bring about co-operation between existing agencies and to enlist the aid of the pure scientist, the universities and every other institute handling scientific questions.[20]

Similarly, Menzies' 'behind closed doors' method of science policy-making[21] is typical of the elitism inherent in conservative notions of aristocracy and the 'natural' evolution of individuals who lead. Fraser continued the conservative tradition by steadfastly opposing the setting up of new formal decision-making science policy bodies, and favouring an ad hoc, non-institutionalised form of policy making.[22] He was gradually persuaded to temper this conservatism as the demands of a more technologically oriented system of production began to require more complex management. When political conservatism meets the organisational conservatism of the scientific community the result can be institutional stagnation which lags behind the changing needs of society.

1.1.d Techno-economism

Techno-economism is the belief, in modern industrialised societies, that the paramount purpose of scientific activity is to furnish knowledge that can be used in the development of innovative technologies useful to achieve national economic objectives. According to this ideology the pursuit of scientific knowledge must always be justified in terms of economic achievement. Pure scientific research is countenanced on the understanding that knowledge of what may in the future be economically useful is presently imperfect. The concept of techno-economism was implicit in Bernal's seminal analysis of the relationship between modern societies

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19 Dennis Altman, 'Social and political barriers', in *The Socialist Objective: Labor and Socialism,* ed. Bruce Meagher , Hale & Ironmonger, Sydney, 1983, pp. 135-157, p. 147.

20 C.B. Schedvin, *Shaping Science and Industry: A History of Australia's Council for Scientific and Industrial Research, 1926-1949,* Allen & Unwin, Sydney, 1987, p. 24.

21 James Davenport, 'The Impulse of Science in Public Affairs, 1945-1986', in *The Commonwealth of Science: ANZAAS and the Scientific Enterprise in Australia, 1888-1988,* ed. Roy McLeod, Oxford University Press, South Melbourne, 1988, pp. 73-96, p. 78.

22 Malcolm Fraser, 'Government Approaches to Science, *The Australian Journal of Science,* vol. 31, no. 12, 1969, pp. 410-415, p. 413.

give new guidelines for the directions the organisation is to take in allocating priorities for research work.[32]

It is unlikely that techno-economism will decline as the major political ideology informing the relationship between governments and scientific activity under an ALP government. Although radical techno-economism has dominated science policy-making by the Hawke government, it is by no means party-specific. The science policy statement of the Liberal and National Parties (issued in November 1988) is equally certain (though perhaps more timid in its re-structuring) of the relationship between the production of scientific knowledge and national economic growth:

> Science and technology are indispensable in achieving a more outward-looking and innovative society. They offer Australian industry a unique opportunity to revitalise and expand its domestic and export markets in an increasingly competitive world.[33]

1.1.f The challenge of environmentalism

Environmentalism may provide a challenge the ideology of techno-economism. The ideology is based on the science of ecology defined as: 'a branch of biology dealing with organisms' relations to one another and to their surroundings'.[34] Groups who use ecological knowledge politically have come to be known as 'environmentalists'. They judge all political issues in light of their impact on the global or local ecology, believing that the values informing human behaviour should be based not on an anthropocentric view of the natural world but on an ecocentric view which denies the moral pre-eminence of the human species.[35] Thus the natural world has moral rights of existence which are separate from humans' perception of the use-value of the non-human world.[36] This view places environmentalists in constant potential opposition to development based on the exploitation of natural resources. Scientific knowledge is used by both sides in the conservation/exploitation debate to influence governments in the allocation of resources to their respective interests, whether they be profits or the objectives of deep ecology.

In the 1980s there have been many indicators of the way in which environmentalism is increasingly significant in science policy. Among them are firstly, the fact that the total membership of the five major environmental organisations in Australia grew by 1200 per cent between 1980 and 1990, thereby

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32 CSIRO, *Annual Report 1987-88,* CSIRO Public Affairs, Canberra, 1988, p. 10.

33 Liberal & National Country Party, *Science Policy: Preparing Today for Tomorrow,* Liberal Party of Australia, & National Party of Australia, Barton, ACT, 1981, p.1.

34 *The Concise Oxford Dictionary,* 7th edn., 1982, s.v. 'ecology'.

35 *The Penguin Macquarie Dictionary of Australian Politics,* 1988 edn., s.v. 'ecological movement'.

36 P.R. Hay, 'The Environmental Movement: Romanticism Reborn?', *Island Magazine,* no. 29, Summer 1986-87, pp. 10-17, p. 11.

increasing the electoral significance of environmentalism.[37] Secondly, concern for the environment has now been formalised in the CSIRO Act. In June 1988, section 13 of the Science and Industry Research Act 1949 was amended to provide new Ministerial Guidelines for the objectives of CSIRO. The first of these is: 'CSIRO's main task will be the conduct of strategic and applied research in support of national economic, social and *environmental* objectives (emphasis added).'[38] Thirdly, there is some indication that funding for environmental research is increasing.[39] The May 1989 Statement was followed by a major Environmental Statement by the Prime Minister in July 1989.[40] The National Greenhouse Advisory Committee was formed in August 1989 to advise the government on developments in global warming and on priorities in this areas of research.

As environmentalism is recognised by governments as a legitimate political lobby, the line between scientific and political activity, between fact and value, is blurred. At present environmentalism's formal political constituency is restricted but its influence has to be seen in terms of its potential for disrupting both the balance of political power and the process of economic production. The political appeal of environmentalism depends upon the global physical climate and the global economic climate. It will wax in the face of substantial evidence of global warming and wane in the face of continuing global and Australian economic recession.

The above political ideologies express the way in which the relationship between the political system and the science system in Australia has been perceived by successive governments. The way in which they developed demonstrates Giddens' notion that groups with sectional interests seek to conceal the fact that most action in society serves their interests. Sectional interests are represented as universal interests. Thus British manufacturing interests were represented as interests of Empire in providing funds for the establishment of CSIR. Rural interests have dominated the allocation of resources to research throughout much of the twentieth century. Manufacturing interests have used government concern over the lack of innovation in industry to bring about tax subsidies for private production.

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37 Brian Woodley, 'How a tiny seed grew into a tree with strong branches', *Weekend Australian,* June 9-10 1990, p. 21.

38 CSIRO, *Annual Report 1987-88,* CSIRO Public Affairs, Canberra, 1988, p. 10.

39 In 1990 ASTEC published a review of environmental research in Australia which included a comparison of environmental research funding in 1984-85 and 1986-87, the only truly comparable years data then available from the ABS. The Council estimated that research funding from all sources during that period had increased by 4.2% in real terms. The Commonwealth Government share of that funding increased by 6%. ASTEC noted that:

> Attempts to assess the status of Australian environmental research are plagued by the subjectivity of practitioners and the shortcomings of more objective means of measurement.

ASTEC, *Environmental Research in Australia: A Review,* AGPS, Canberra, 1990, pp. 16-19 & 83.

The Science and Technology Budget Statements do not separate environmental research from other program research such as energy.

Australia, *Science and Technology Budget Statement, 1991-92,* Table 2, p. 92.

40 Australia, *Our Country, Our Future: Statement on the Environment,* The Hon. R.J.L. Hawke, Prime Minister of Australia, AGPS, Canberra, 1989.

The ideologies both arise from, and are generative of the way in which the science policy community is structured. These constituent elements of the science policy community are described and analysed in chapter four. The interests and objectives of scientific actors in the science policy community are derived in large part from their socialisation in the Australian scientific community. Concepts for an analysis of the production of scientific knowledge were outlined in chapter one. The following section describes the development of the institutions of Australian science in the light of these concepts.

2. THE AUSTRALIAN SCIENCE SYSTEM

This thesis is concerned with science policy in four main sectors of activity: the higher education system, government research institutions, rural research organisations and the manufacturing sector. The most significant actors in the science system, and science-based members of the policy community, emerge from institutions in these sectors each of which has its own distinctive pattern of organisation and production. The four sectors will be examined throughout subsequent chapters which explore the formation of rules for, the development of ideas about, and the allocation of resources to, scientific research in Australia.

2.1 Higher education research

The higher education sector in Australia has two direct basic functions within the science system: the training of scientists and the production of scientific knowledge. A third function, integral to these two, is the perpetuation of the science system itself. The development of individual institutions, and the establishment of associated peripheral organisations have centred around these functions.

2.1.a The production of scientists and scientific knowledge

Higher education research in Australia has been conducted in universities, agricultural, technical and mining institutes and, increasingly in the late 1980s, in colleges of advanced education. The first universities in Australia were not established until the decade of colonial independence in the 1850s-60s. Sydney University was first in 1852 followed closely by Melbourne in 1855. They were modelled on London University, founded in 1826 with seventeen chairs of science, rather than the Oxbridge system which emphasised classics.[41] For a hundred years they were funded mainly by State governments.

The traditional British separation of commerce and academe was adopted in Australia. Agricultural and technical education began outside the universities as agricultural colleges and technical institutes were established in the 1880s. The University of Sydney did not get a Chair of Agriculture until 1910 despite the

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41 Ann Mozley Moyal, *Scientists in Nineteenth Century Australia*, Cassell Australia, Sydney, 1976, p. 221.

economic dependence on rural industry.[42] The influx of scientists from Britain in the 1880s reinforced the British model of autonomous university research although individual scientists such as Masson in Melbourne did see his chemistry teaching and research as part of a wider industrial scientific effort. There was no attempt at this stage, or later after the First World War when the success of the German university/industry research model became apparent, to develop a uniquely Australian model of university research. Australian scientists continued to be trained in the British mode and to base their careers on success in Britain rather than Australia.[43]

At the end of the Second World War there was an attempt to move universities away from the British model. The establishment of the Australian National University in Canberra as a tertiary institution devoted to research offered Australian scientists a place of excellence for research in Australia. The original idea was formulated by Oliphant and Chifley using Princeton University as a model. The founding of the New South Wales University of Technology (later the University of New South Wales) in 1949 on the model of the Massachusetts Institute of Technology was also intended to herald a new era in which the scientific knowledge produced in universities was to be focussed on local economic production as well as on recognition in the international scientific community. However, both universities were later re-oriented to the British model by the anglophile Menzies.[44]

By 1965 the Commonwealth government had assumed financial responsibility for tertiary education in Australia and research in universities was funded partly through general university funding and partly on a competitive basis through the Australian Research Grants Scheme (ARGS). ARGS was intended to allocate resources to 'the most outstanding and promising research being carried out in universities and non-government research institutions'.[45] The Scheme thereby maintained the lack of co-ordination between university research and that undertaken in government laboratories. Thus, in 1977, the first ASTEC Report concluded that: '...steps need to be taken to improve the interaction between universities and colleges, industry and government laboratories'.[46] Several universities have since

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42 Ibid., p. 237.

43 R. W. Home, 'Introduction', in *Australian Science in the Making,* ed. R. W. Home, Cambridge University Press, Melbourne, 1988, pp. vii-xxvii, pp. xiv-xv.

44 Davenport, 'Science in Public Affairs', p. 82.

45 D.M. Lamberton, *Science, Technology and the Australian Economy,* Tudor Press, Sydney 1970, p. 36.

46 The Report quoted the work of Sir Ian McLennan who showed that from 1970-75, of 66 patented innovations in Australia, only three had originated in university laboratories. Ten years later ASTEC was still advocating the closer liaison of industry and university research on the grounds that the social and economic returns on the investment made by the allocation of public resources to the production of scientific knowledge in universities were inadequate.
ASTEC, *Science and Technology in 1977-78,* AGPS, Canberra, 1978, pp. 5 & 87.
ASTEC, *Improving the Research Performance of Australia's Universities and Other Higher Education Institutions*, AGPS, Canberra, 1987, p. 3.

tried to bridge the gap between their scientists and industry by establishing entrepreneurial companies to manage the exchange of ideas and funds between firms and university laboratories.[47]

In the late 1980s the higher education research system has undergone radical changes as political expectations of the science system based on conservative and colonial ideologies have been challenged by techno-economistic ideas of the relevance of research to national economic production. The unification of the higher education system has meant the incorporation of the former institutes of advanced education into the university research system. This has increased competition for research funds and diluted the ethos of international competent response by encouraging researchers to derive their status from other arenas of action.

2.1.b The perpetuation of the norms of science

Societies which foster the norms of science and which reward scientists and recognise scientists' work through the mechanism of competent response have traditionally been an essential part of national science systems and of the global system of science. In Australia such societies are closely associated with universities. Not until the 1980s did a different type of scientists' agency emerge in the form of representative bodies rather than agencies concerned with the reinforcement of scientific norms.

The earliest scientific societies and associations in Australia were established as foci for the practice of Bernal's 'Gentlemen's science'.[48] The early colony had no resources or inclination to pursue scientific enquiry, or as Moyal, expresses it, '...no money or men'.[49] By the 1880s the scientific community in Australia had been institutionalised into one of government and university scientists but as yet had not developed an Australian focus. The establishment of ANZAAS in 1888, as a federal body which pre-dated the political federation of Australia by thirteen years was in fact the expression of the scientific community's desire that Australia should be represented by one association in the halls of imperial science in Britain.[50] This colonial tendency of the Australian scientific community to regard itself as part of the British scientific community, rather than existing in the global scientific community in its own right, continued unchallenged until the end of the Second World War.

The cost of anglo-centrism was that no integrated scientific community developed in Australia. In the 1950s the ideological link with the British system of

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47 The 1978 ASTEC Report said that the initiatives were 'laudable' but too small and fragmented. ASTEC, *Science and Technology in 1977-78,* vol. 1A, p. 87.

48 Bernal, *Science in History. Volume 3: The Natural Sciences in Our Time,* p. 719.

49 Moyal, *Scientists in Nineteenth Century Australia,* p. 107.

50 Roy McLeod, 'Organizing Science under the Southern Cross', in *The Commonwealth of Science: ANZAAS and the Scientific Enterprise in Australia 1888-1988,* Oxford University Press, Melbourne, 1988, pp. 19-39, pp. 30-39.

science was formalised with the establishment of the Australian Academy of Science (AAS). Although the Academy did not use the prefix 'Royal' it was modelled on the British society and duplicated its ethos and organisational structure.[51] The Academy perpetuates the norms of science by conferring high status upon Australian scientists who conduct their research appropriately and achieve international recognition of their competence. During the Menzies' era the Academy was immensely influential in the allocation of resources to the Australian science system in general and the higher education research system in particular. Situated in the precincts of the Australian National University in Canberra, the AAS maintained a monopoly over the status system of science and was authorised by the Commonwealth government to interact with the international science system on behalf of Australia.

In 1976 the Australian Academy of Technological Sciences and Engineering (AATSE) was established by scientists employed in industry who felt that the AAS was not acknowledging the contribution of scientists working in applied disciplines. The AAS came under pressure from Fellows who were working in applied fields to change its policy but successive Presidents decided that the ethos of the AAS was to foster good basic science and that applications would automatically follow. This was not a satisfactory response to those Fellows who wished to have more influence on technology policy in Australia and the new Academy was formed.[52] This widening of the status system of science heralded the formation of other representative bodies in the 1980s.[53]

2.2 Government research

In the Australian science system government research agencies have been pre-eminent in the production of scientific knowledge. Scientists from this sector dominated the science policy community until the advent of techno-economism began to formalise science policy-making in the late 1960s.

2.2.a Research in the Commonwealth public sector

The major stimulus for research and development in Australia comes from the Commonwealth government. Forty per cent of Commonwealth expenditure on research and development is spent on scientific activity in Commonwealth research

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51 In 1951 a closed seminar in celebration of the Jubilee of federation was held at the newly-established Australian National University in Canberra. In February 1954 the Queen personally handed to Oliphant the Charter of the Australian Academy of Science.
In 1990 the Academy has 260 Fellows and receives 25 per cent of its funding from the Commonwealth Government.
The Australian Academy of Science, *The first twenty-five years,* Australian Academy of Science, Canberra, 1980, pp. 11-14.
Professor Ian Ross, Secretary, Science Policy Committee, Australian Academy of Science, Interview, 5.4.90.

52 Professor H. Worner, Director, Microwave Research Unit, University of Wollongong, Personal Communication, 3.11.89.

53 This issue is discussed at greater length in chapter three.

agencies.[54] Since 1974 the largest agency in terms of financial and human resources has been CSIRO.[55]

The establishment of a Commonwealth government-funded research capacity arose because of increasing concern that certain problems facing economic production were not be satisfactorily managed by State departmental research laboratories. Between 1908 and 1926 there was a protracted debate over the constitutionality, rationale, functions and structure of a federal research institution which would produce such knowledge. The other major factors in the decision to proceed with establishing such an institution were the isolation imposed by the First World War, Hughes' nationalistic desire for an Australian research organisation and Britain's desire to exploit the research capacity of her colonies.[56]

The Council for Scientific and Industrial research (CSIR) became the umbrella organisation for a diverse range of research activity but there was a definite bias in favour of rural research. By 1935 the focus was still on primary industry despite the Council's charter to undertake research for manufacturing industry as well.[57] It was the threat of war and disrupted imports of manufactured goods which galvanised the Commonwealth government into expanding its research activity into the areas of manufacturing industry and defence.

After the Second World War governments began to realise that modern social life depended to an increasing extent on a level of scientific knowledge production which needed some degree of diversification and co-ordination. The Labor government set up a Commonwealth Department of Post-war Reconstruction, led by the Minister-in-Charge of CSIR, to begin the process of reviewing Australia's post-war scientific needs. The establishment of the Bureau of Geology, Geophysics and Mineral Resources, the Defence Research and Development Policy Committee and the re-organisation of CSIR into CSIRO were all part of this process.[58]

In contrast, during the Menzies governments, scientific activity in the federal sphere was constrained by Menzies' conservative notions of the role and functions of the state. The rate of increase of scientific staff in Commonwealth government departments levelled off considerably from 1955-60 and, of the eleven government

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54 Australia, *Science and Technology Budget Statement 1991-92,* p.101

55 In 1965 CSIRO accounted for 28% of financial resources allocated to major research agencies in 1990 dollar values. By 1990 this had increased to 45%. The major loser has been the Defence Science and Technology Organisation (DSTO) which accounted for 47% in 1965 (as the Weapons Research Institute) but only 25% in 1990. A more detailed account of the allocation of resources to research and development is given in chapter 5.

56 See Sir George Currie & John Graham. *The Origins of CSIRO: Science and the Commonwealth Government 1901-1926,* CSIRO, Melbourne, 1966, chapter 1; and Schedvin, *Shaping Science and Industry,* chapter 1.

57 In that year only 4.3 per cent of the budget was spent on non-rural research and of that tiny amount 65 per cent was spent on mining and metallurgy research and the remainder on radio research.
Australia, Council for Scientific and Industrial Research, *Ninth Annual Report,* Parliamentary Papers, Commonwealth Government Printer, Canberra, 1935, pp. 92-95.

58 Davenport, 'Science in Public Affairs', pp. 75-78.

laboratories outside CSIRO, only two, the Ionospheric Prediction Service and the Biological Standards Laboratory, were established after 1948.[59] Until 1963 portfolio responsibility for scientific activity lay with the Minister-in-Charge for CSIRO. This reflects the narrowness of the organisational research base in Australia and the fact that research in universities was not considered to be part of national economic production. Even more (68 per cent) of CSIRO's budget was devoted to rural research than in 1935 and a large proportion of the remaining funds were for research in mining and metallurgy.[60]

From 1965 to 1990 there has been an intensification of techno-economism in the conduct of research in the federal public sector characterised by diversification of the means of scientific knowledge production funded by the Commonwealth government, by vastly increased research subsidies for secondary industry and by government insistence that an increasing portion of public sector scientific agencies' budgets should be earned from external sources. In 1985 CSIRO funds accounted for nearly 50 per cent of direct appropriations to research agencies. By 1990 that had decreased to 45 per cent.[61] Other research agencies have been established (Australian Institute of Marine Science, Co-operative Research Centres) or enlarged (Antarctic Division) breaking the monopoly of CSIRO on the production of non-medical, civilian, scientific knowledge, but none have yet come close to challenging the Organisation's supremacy.

2.2.b Public sector research in the States

For the first 120 years of European settlement all scientific activity was funded privately or by State governments. The production of scientific knowledge by government departments in the States has traditionally been concerned with solving problems of primary industry, developing infrastructure and services, providing expertise for running the States' public enterprises and fulfilling the States' responsibilities in such areas as health, education and welfare.[62]

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59 R.W. Boswell, 'The Interaction and Development of Science in Government and Science in Industry', *Public Administration,* vol. XXVII, June 1968, pp. 141-165, pp. 149-151.

60 Commonwealth Scientific and Industrial Organisation (CSIRO), *Eighteenth Annual Report,* Parliamentary Papers 1964-65-66, Commonwealth Government Printer, Canberra, 1935, pp. 92-95.

61 A more detailed account is given in chapter 5.

62 Federation required stipulation of the specific responsibilities of the new Commonwealth government. These responsibilities are given in the Constitution in several sections, but the majority of the exclusive powers of the Commonwealth are included in the forty subsections of Section 51. There is no specific reference to science or research activities in Section 51 but many of the subsections concern government responsibilities which use scientific knowledge. For example:

- (v) postal, telegraphic, telephonic and other like sevices;
- (vi) defence and law enforcement;
- () astronomical and meteorological observations;
- (ix) quarantine;
- (xv) weights and measures;
- (xviii) copyrights, patents of inventions and designs;
- (xxiiiA) provision of health services.

Government laboratories concerned with production problems in the rural industries were established in the second half of the nineteenth century. These research activities grew as industrialisation, pastoral development, fisheries, forestry and mining exploration gathered pace in the twentieth century. Departments and statutory bodies such as the Hydro-Electric Commission in Tasmania, the Geological Survey of New South Wales and the Victorian Brown Coal Research and Development Committee built up large bases of expertise and service delivery with substantial research and development input.[63]

In the 1980s many State governments have developed outreach services to assist State-based companies relying on high technology or scientific expertise to establish their enterprises. State enterprises have also been encouraged to market their services and products. Initiatives in high technology led to the development of science and technology parks in all States and many States have set up agencies to act as intermediaries in the transfer of scientific knowledge from public sector research organisations to private producers. An example is Daratech in Victoria which the government established in 1987 to assist local industry in the use of the knowledge produced by the Department of Agriculture and Rural Affairs. State governments are also providing venture capital so that public sector research can be developed by private companies.[64]

2.3 Manufacturing research

In contrast to the rural sector, the manufacturing sector of economic production in Australia has traditionally had a low utilisation rate for scientific knowledge. The use of imported technology has been a characteristic of non-rural manufacturing in Australia. Hill has termed this aspect of Australian culture 'technophilic'. He describes it thus:

> A characteristic symbol of the history of technological change in Australia is that we adorn our civilisation with technology trinkets. They are not things that we work up and with. They are not emergent from the culture. We stick them round our cultural neck and play with them ...so that when new technology such as colour T.V.s comes in the market is saturated in a very short time. We wait and absorb the technological culture that comes to us.

In addition to the above areas covered in Section 51, subsection xxxvii allows the Commonwealth government to assume any responsibility referred to it by State Parliaments. Thus, for example, although education is a residual power of the States since it is not referred to in the Constitution, the States agreed in the late 1950s to allow the Commonwealth government financial responsibility for the universities. This action has transferred to the Commonwealth government control over an important sector of research in Australia because the basic training of scientists is conducted almost exclusively in universities.

63 ASTEC, *Science and Technology in 1977-78,* vol. 1B, p. 122.

64 Bureau of Industrial Economics, *Commercial Opportunities from Public Sector Research,* Research Report 32, AGPS, Canberra 1990, pp 22-23.

> Businesses do it as well. They don't unpack the social and cultural dynamics behind the black boxes they import.[65]

Professor Howard Worner claims that there are only five Australian manufacture and mining companies which have made substantial contributions to Australian science. They are BHP, ICI Australia, Western Mining Company, Conzinc Riotinto of Australia and Repco (before being taken over). Other companies have maintained laboratories, but these have usually been to solve problems of production rather than to innovate.[66]

The impression obtained is that decision-makers in Australian industry are chronically reluctant to use scientific knowledge to innovate and develop products. Many of the scientists interviewed during research for this thesis have an enormous range of experience in Australian and overseas industry. Such scientists as Dr. Alexandra Pucci, Professor Arthur Birch and Professor Richard Collins confirm this view that, in general, the relationship between private sector manufacturing production and the production of scientific knowledge in Australia has been fragmented and sporadic.

In the 1980s the scientific inertia of the manufacturing sector began to change. In new areas of technology, industry associations have developed not only to foster research and knowledge transfer in the manner of the older research associations but also to oversee the way in which the industry develops in Australia by campaigning on its behalf with State and Commonwealth governments to simplify and expedite such interactions as new regulations and uniform standards. The Medical Industry Association of Australia Inc., the Australian Robot Association and the Australian Biotechnology Association are three examples of such agencies.[67] More recently interdisciplinary sciences such as biotechnology and computer science have set up associations to foster and co-ordinate the commercialisation of the products of their work. The boards of such agencies often act in a representative capacity for research activities in a particular industry.

2.4 Rural research

Research for rural industry is the longest-established applied science in Australia. Although not strictly part of the scientific community, rural research associations and councils are an integral and influential part of scientific activity in Australia. They are basically groups of individual firms and producers who combine resources to sponsor common interest research and development, usually on an industry-wide basis. The research is undertaken by State government research agencies, CSIRO

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65 Professor Stephen Hill, Centre for Technology and Social Change, University of Wollongong, Interview, 3.11.89.

66 Worner,Personal Communication, 3.11.89.

67 *Scitech Technology Directory 1992 Edition,* Jane Ford (compiler), Scitech Publications, Canberra, 1992, pp. 226-232.

and the universities, but some industries, such as the Australian Wine Research Institute or the Sugar Research Association have traditionally run their own laboratories.

The first attempt to raise funds for specific rural research was in 1927 when members of the Australian Wool Growers Council and the National Council of Wool Selling Brokers launched an appeal to establish a pastoral trust fund to finance research to improve the quality of wool fleeces.[68] Three years later the fifth CSIR annual report listed the New South Wales and Victorian Meat Exporters Association, the Australian Pastoralist Research Trust and the Australian Dairy Council as contributors to the cost of specific research programs.[69] By 1955 there were 21 such associations or councils listed as contributing funds to CSIRO research.[70] The even greater significance of the wool industry was apparent in 1965 when the Wool Trust Fund contribution to investigations was $5 million or twenty per cent of total Treasury funding for research at CSIRO in that year.[71]

The growing number, importance and success of the rural research associations was recognised by consecutive governments in the 1960s and 1970s. Associations were transformed into Rural Industry Research Funds for a wide range of smaller rural producers in such industries as oilseeds and cotton. Each dollar raised for research by producers was matched, or partly matched, by the Commonwealth government. In the 1980s the concept has been refined by the Hawke governments so that small rural enterprises can receive funds for research and development from the Special Rural Research Fund which became, in 1990, the Rural Industries Research and Development Corporation.[72]

This brief account has described the basic institutional context for activity in the science system in Australia. The general picture is of a set of institutions closely modelled on similar British institutions and therefore predisposing scientific activity towards similar patterns of interaction with the rest of society. Probably the most significant change in science policy in the last twenty five years has been the decreasing autonomy of scientists within publicly funded research agencies both in terms of the selection and organisation of research, and in the uses to which that research is put. Later chapters will analyse the causes and describe the outcomes of such changes. Fundamental to the techno-economistic ideology of political actors in the science policy community is the need to reverse Australia's deteriorating trading

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68 Shedvin, *Shaping Science and Industry,* p. 85.

69 Council for Scientific and Industrial Research, *Fifth Annual Report,* Parl. Paper 25 Canberra, 1931, p. 45.

70 The largest contribution was from the Wool Research Board which spent £560,000 on research in that year. This represented fourteen per cent of CSIRO's total expenditure on research in 1955. CSIRO, *Seventh Annual Report,* Parl. Paper 110, Canberra, 1955, p. 180-181.

71 CSIRO, *Eighteenth Annual Report,* p. 8.

72 Australia, *Science and Technology Budget Statement 1989-90,* Budget Related Paper no. 10, AGPS, Canberra, 1989, p. 49.

position. The final section of this chapter gives a brief description of this situation as it impinges on science policy. Before such issues are discussed, however, it is necessary to understand the way in which political actors and scientists interact. We need to appreciate the currency of their mutual interests: knowledge and power.

3. POLITICAL INTERESTS AND SCIENTIFIC INTERESTS

Action in the science policy community is oriented around two distinct types of interests: political interests and scientific interests. Action in the science system is informed by a unique set of norms, elucidated in chapter one, which function to protect the validity of knowledge produced by the scientific method of the formulation of testable hypotheses. Action in the political system is informed by the particular ideologies of the dominant coalition of political actors. Conflict between the two systems arises when the actions of one system are evaluated using the ideologies of the other system. Political objectives for scientific knowledge may be seen by scientists to violate the norms of science. Scientific norms may be seen by political actors as obstructing social and economic objectives. Consequently, science policy also consists of negotiations over the control of rules, resources and ideas not only concerning the production of scientific knowledge but also the uses to which that knowledge is put. The media of negotiation are knowledge and power.

3.1 Government and science

Governments need scientific knowledge to inform the process of governing; to solve societal problems such as natural disasters, environmental problems, health crises and defence requirements; and as a source of innovative productive capability. Scientists need governments to supply financial, human and ethical resources for the process of creating new scientific knowledge. The relationship is therefore an exchange relationship between resource interdependent systems of action. The basic exchange nature of the relationship exists in all industrialised nations. What differs between countries is the degree and nature of the dependencies which emerge from the interaction of the universally-accepted scientific method of the creation of new knowledge and the various forms and practices of different political systems.

3.2 Political interests

Governments need scientific knowledge in two main forms. Firstly, scientific knowledge and systematic methods of organising and analysing information are needed by governments to manage the complexity of modern life. For example, mass health care, transportation, education and defence are functional areas of the provision of goods and services by governments which require scientific expertise. Secondly, governments need to stimulate the production of scientific knowledge for economic, social and cultural development in societies. Brooks used the terms 'science in policy' and 'policy for science' to categorise these two different ways in which the scientific community and governments interact. He emphasised that the two aspects are often closely linked, and gives the example of the way in which scientific advice on the nuclear test ban treaty (science in policy) led to government funding for seismological research (policy for science).[73]

Scientific knowledge may be received by governments either directly from the scientific community acting within government laboratories, from quasi-government research institutes or from private laboratories undertaking government contracted research. Scientific knowledge funded by governments may also be privately produced for private use with the owners of production acting as government agents to achieve national objectives. Governments employ scientists, who may or may not also be involved directly in scientific research, in order to advise them about the use of knowledge which may be very specialised. When scientists act in such a capacity they are acting as political agents and are therefore subject to the demands and interests of the political system and the values and ideologies which inform it.

3.3 Types of scientific knowledge

The attention which scientists give to classifying the types of knowledge they produce is a function of the importance of knowledge in the science system. Knowledge is their commodity of exchange and scientists are located in the system by the type of knowledge they produce. Consequently, policy analysts and actors in the political system must be aware of the nuances of research-defining terminology and the social status of science which underlies it. The most widely-recognised differentiation outside the scientific community is that between 'pure' research which has no immediate practical application; and 'applied' research which is undertaken with definite practical objectives in mind.[74] The low status of applied science in Australia has been responsible for much resistance within the scientific community to changing science policy objectives.[75]

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73 Harvey Brooks, *The Government of Science,* The MIT Press, Massachusetts, 1968, p. 85.

74 In the science system applied scientists (producing tactical problem-oriented science according to the ASTEC categorisation) were generally regarded as being of lower scientific standing. Consider this report of a remark made by one of Australia's best-known basic scientists at the Commonwealth Jubilee Seminar in 1951:

> Professor Huxley said that he did not believe that applied science was more difficult than pure science. It was unpopular with scientists because it was dull. Top physicists, etc., who were working in applied fields during the war, got out of these fields as soon as possible after the war ended.

Australian National University, *Science in Australia,* F.W. Cheshire, Melbourne, 1952, p. 176.

75 The research dichotomy pure/applied has overtones of the religious sacred/profane dichotomy implying that-which-is-to-be-worshipped being distinguished from that-which-is-mundane. The separation of the Australian Academy of Technological Science and Engineering from the Australian Academy of Science in 1976 can be seen as the beginning of the end for the elite status of basic science in Australia. In 1990 the corporatisation of the production of science, with the concomitant status rewards for applied scientists means that pronouncements such as Huxley's are now few and far between.

3.3.a The Dainton typology

In 1971 Sir Frederick Dainton further differentiated the types of knowledge that scientists produce by distinguishing between the various types of stimulus which caused the knowledge to be sought in the first place. He sees the range of scientific activity as a spectrum of research.

3.3.a.i Basic science

At one end of the spectrum is basic science which is undertaken, often by individual scientists, to specifically to extend knowledge by answering a problem of theory, ideas or research results which don't fit any known paradigm. The time frame to produce this sort of knowledge is typically long and its application to practical problems may not occur for many years.

3.3.a.ii Tactical science

For research at the other end of the spectrum Dainton coined the term tactical science to denote that science which has an immediate practical application in the short term either as providing an answer to an immediate problem or by providing the knowledge for goods and services to be produced. This type of research is predictable and requires only relatively minor changes to current knowledge.

3.3.a.iii Strategic research

In between these two types is strategic research. This is carried out because a collective body of opinion decides that research in a certain direction will be useful in the middle term but at the time of the decision being made has no practical problem to answer or no known scientific gap to fill. The boundaries between these types of knowledge are not rigid. Knowledge created during tactical research may help to fill holes in knowledge and knowledge created during basic research may have immediate commercial application.[76]

3.3.b The ASTEC typology

In 1978, the newly-constituted Australian Science and Technology Council (ASTEC) felt the need to explain other terms which had been used to define different types of research. The Independent Inquiry into CSIRO had used three categories of research and ASTEC wished to amplify this schema.[77] As in the Dainton definitions the distinguishing characteristic is the primary objective for which research is undertaken. The ASTEC definitions are:

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76 Frederick Dainton, 'Are Some Science Policy Issues Inevitable, Irresolvable and Permanent?', in *The Management of Science,* ed. Douglas Hague, Macmillan, London, 1991, pp. 47-68, pp. 49-51.

77 The types are:
fundamental: to contribute to the discipline;
strategic mission-oriented: to contribute to a definable problem area, maybe long-term;
tactical problem-oriented: to give answers to definable, short-term problems.
Australia, *Independent Inquiry into CSIRO*, AGPS, Canberra, 1977, p. 9.

- *basic research (fundamental)* to acquire new knowledge of the underlying foundations of phenomena and observable facts without any particular application or use in view;

- *tactical problem-oriented research* (as Dainton above)

Basic research may further be divided into:

- *curiosity-motivated research* pure basic research; and

- *strategic mission-oriented research* (as Dainton above)

ASTEC explains the difference between these sub-categories (which they see as largely 'an attitude of mind'- presumably on the part of the scientists) with a quaintly Australian example:

> Studies on the physiology of the koalas would be described as curiosity-motivated research; but similar studies on sheep could be strategic mission-oriented research, as the expectation of practical benefit is ever-present. Nevertheless a study of the physiology of koalas could produce results of great scientific importance which could, in time, be of great practical value also. After all, koalas are extraordinary. They eat only certain types of eucalyptus leaf and therefore ingest large quantities of essential oils: and they do not drink water.[78]

3.4 Scientific interests

The interests of scientists fall into two broad categories: the need for financial resources to pay for costly training, skills, and technology; and ethical needs to ensure the legitimacy of their actions in the wider society.

3.4.a Financial resource needs

The production of scientific knowledge in the second half of the twentieth century needs considerable financial resources. Bernal gives some idea of the scale of the increasing cost to governments of the production of scientific knowledge. He estimates that, between 1937 and 1962, the cost to the US Government of civil science increased by a factor of forty eight. In the same period the cost of US military science rose by a factor of 560.[79] For Bernal such a scale of expenditure is an indicator of the changing relationship between science and society. He sees the transformation as occurring in three phases:

> ...in the nineties we are still in the era of *private* science, that of the small laboratory of the professor or the backroom of the inventor. The next stage, first evident in the twenties and thirties of the new century, is the era of *industrial* science, that of the research laboratory spending a few tens of thousands of pounds, and of the correspondingly expanded university department and the now subsidized research institute. The third stage, appearing first in the Soviet Union but becoming universal in the Second

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78 ASTEC, *The Direct Funding of Basic Research,* AGPS, Canberra, 1978, p. 8.

79 Bernal, *Science in History. Volume 3: The Natural Sciences in Our Time,* p. 847.

> World War, is that of *governmental* science, where the expenses of research and development run into hundreds of millions of pounds and establishments as large as towns are needed to house the men and equipment needed for it. For this only the State can find the money, though it may call upon the assistance of monopoly firms, themselves almost States in their own right, to spend it for them in the form of development contracts.[80]

Such vast commitments of public money in democratic societies inevitably requires justification to the taxpayer. Governments increasingly need to legitimate their decisions by publicising and documenting the criteria by which choices are made. The size of the funds scientists demand always exceeds the resources that governments are prepared to allocate to the production of scientific knowledge.[81] One of the changes occurring in the Australian science policy community has been the increasing scrutiny to which Parliament is subjecting public funds allocated to research and development. The 1989 Auditor-General's Report on External Funding for CSIRO, and the 1991 Joint Committee of Public Accounts Inquiry into Public Sector Research are prominent examples of this trend.[82]

3.4.b Legitimation needs

Power, in the form of enforcing the rules inherent in scientific norms, is exercised in the scientific community as control over the institutions in which such knowledge is produced. Because the norms of science described above are in many ways antithetical to other societal norms (for example, the norm of universalism, which encourages the investigation of all natural phenomena, may be in conflict with religious norms) it is desirable for scientists that scientific research is isolated from other societal institutions. One of the functions of government legitimation of research activity is the delegation to the scientist of political responsibility for the outcomes of such activity.

The ethical dilemma posed for governments by the scientists' norm of universality was recognised by Max Weber in 1918. Weber is concerned with the question of whether those who pursue science as a vocation have the right to determine the value of the knowledge they produce for the rest of society. He concludes:

> Science ... presupposes that what is yielded by scientific work is important in the sense that it is 'worth being known'. In this obviously are contained all our problems. For this presupposition cannot be proved by scientific means. It can only be *interpreted* with reference to its ultimate meaning, which we must accept or reject according to our ultimate position towards life....Natural science gives an answer to the question of what we must do if we wish to

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80 Ibid., p. 719.

81 OECD, *Science, Growth and Society - A New Perspective,* (the 'Brooks Report'), 1971, pp. 16-17.

82 Australian National Audit Office, *Commonwealth Scientific and Industrial Research Organisation - External Funds Generation,* Parl. Paper 202, Canberra, 1991.
Australia, Joint Committee of Public Accounts, *Public Sector Research and Development,* Report 318, AGPS, Canberra, 1991.

> master life technically. It leaves quite aside, or assumes for its own purposes, whether we should and do wish to master life technically and whether it ultimately makes sense to do so.[83]

It is this aspect of the interpretation of the value to the rest of society of the products of activity in the scientific community which forms the basis of the dependence of scientists on governments for the ethical opportunity to pursue the creation of new scientific knowledge.

In any society the balance between the autonomy and social control of the science system is the result of a continuously negotiated exchange. As scientists' capacity to manipulate the 'natural world' comes closer to sacred notions of spiritual significance such as 'creation' then such negotiations are no longer abrogated to scientists but become open to political input in the form of ethics committees. The establishment of the Genetic Manipulation Advisory Committee is an example of this trend. Although such fora are not included in this analysis they will undoubtedly form an increasingly important part of science policy as genetic manipulation becomes the norm in many scientific disciplines.

The extent to which science policy is negotiated rather than imposed depends upon the extent to which the science system is dependent on government funding and legitimacy, and to which it can muster support from the wider community for its autonomy. Scientists are then likely to invoke concepts such as Merton's and Storer's, and other beliefs about the way in which scientific knowledge is produced in order to defend their organisational autonomy and to guarantee the future support of their system by governments.

The financial support and organisational autonomy of the science system are under increasing scrutiny as Australia's deteriorating trade position in the global economy causes questions to be asked about the benefits to the Australian community of public expenditure on research and development. The orientation of scientists towards pure science disseminated to the international scientific community, rather than applied research which can be used to add value to Australian exports then becomes an obstacle to the government's objectives of restructuring the economy. The need for such restructuring is discussed in the final section of this chapter.

4. AUSTRALIA'S CHANGING ECONOMY

One of the most significant changes in science policy between 1965 and 1990 has been the extent to which the production of scientific knowledge in Australia has become linked to national economic production and to Australia's position in the global economy. Therefore an understanding of the economic context in which

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[83] Max Weber, 'Science as a Vocation', in *From Max Weber: Essays in Sociology* eds. & trans. H.H. Gerth and C. Wright Mills, Routledge and Kegan Paul Ltd., London 1967, pp. 129-156, pp. 143-144.

policy-making occurs is necessary for an analysis of science policy for two reasons. Firstly, as mentioned in the Introduction, in 1965 the production of scientific knowledge was detached from issues of national economic well being, apart from research conducted for a few rural industries. The structural, ideational and ideological reasons for this detachment form a major theme of the thesis and are discussed at length in chapters three and four. By 1990 science policy has become an important element in the process of the restructuring of national economic production. The transition has occurred through restructuring informed by techno-economism as the motivating political ideology in science policy. Secondly, the production of scientific knowledge depends to a large extent on the capacity of national economic production to provide the resources to support the science system. A diminishing rate of wealth generation forces, at best, a steady state of resources with which to fund research. Prioritisation processes reduce the autonomy of scientists in their selection of research projects. The benefits of the public funding of research, and the use to which research results are put, become issues of economic as well as science policy. This section of the chapter examines the economic indicators which are used in justifying the continuing allocation of public resources to the production of scientific knowledge.

4.1 The structure of Australia's economy 1965 and 1990

Economic production in Australia has undergone significant changes between 1965 and 1990. In terms of science policy the most significant indicators are the proportion of GDP produced by each sector of the economy; the level of imports and exports; and the level of foreign ownership of industries.

4.1.a Gross Domestic Product and Industry

GDP is the most widely used single indicator of economic well being and growth in an economy. It is a measure of the final consumption or investment value of all goods and services produced in an economy over a given period of time (not including income from overseas investment). By measuring the GDP per capita over time it is possible to gain a crude measurement of productivity in an economy. Thus from 1965 to 1990 the GDP per capita in Australia grew from $9,500 to $15,600 in real terms which indicates that overall productivity increased by 64 per cent in 25 years. This compares with a 97 per cent increase for Canada, and a 63 per cent increase for Sweden over the same period.[84]

Figure 2.1 illustrates the contribution to GDP of different sectors of economic production in Australia in 1965 and 1989. The greatest increases have been in the services sector, particularly in finance, community services and ownership of dwellings. The proportion of GDP contributed by manufacturing industry has fallen

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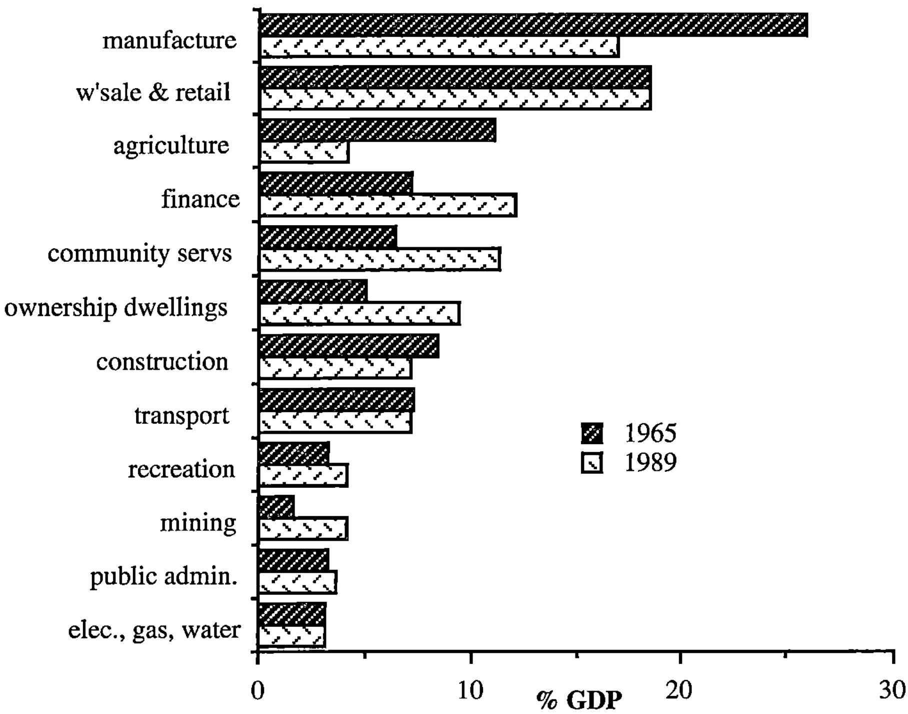
[84] Ibid., pp. 276-277.

from 26 to 17 per cent - a fall of 65 per cent. The only other sector to register a fall in contribution was the agricultural sector which decreased by 38 per cent from 11 to 4 per cent of GDP.[85]

Figure 2.1: Australia, GDP by industry sector, 1965 and 1989



Data source: R.A. Foster and S.E. Stewart, *Australian Economic Statistics 1949-50 to 1989-90,* Ambassador Press, Canberra, 1991, p. 214.

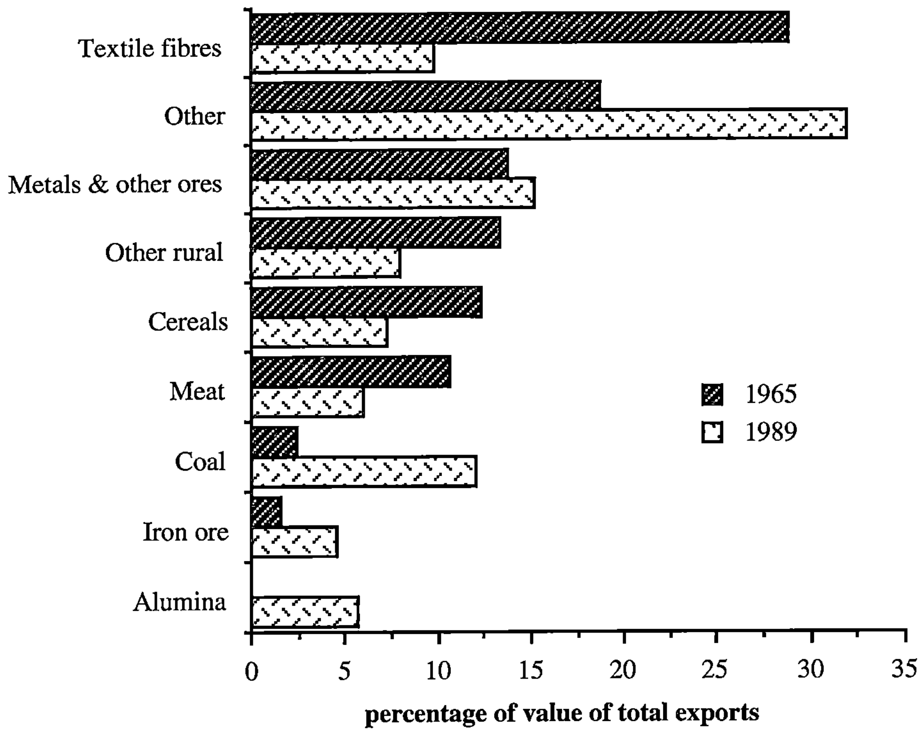
4.1.b Exports and imports

Another indicator of a nation's economic well being is the balance of payments. The flow of capital, the balance between imports and exports and the nature of the goods and services exchanged indicates the way in which a country trades with the rest of the global economy.[86] Figures 2.2 and 2.3 illustrate the most significant categories of exports and imports in terms of a percentage of the total for 1965 and 1989.

85 Ibid., p. 214.

86 *The Penguin Dictionary of Economics*, 3rd edn., Penguin Books, UK, 1984, s.v. 'balance of payments'.

Figure 2.2: Australia, the most significant exports by commodity group, percentage of total value, 1965 and 1989



Data source: Foster & Stewart, *Australian Economic Statistics 1949-50 to 1989-90,* p. 9.

The most dramatic change has been the decreasing value to national exports of textile fibres. The largest single commodity in this group is wool and the comparison illustrates the importance of wool exports to the nation's economy in 1965. Other rural commodities have also fallen in level of contribution. The largest single category increases have been in the mining industry. In 1965 Australian economic prosperity was primarily based on rural industries which provided 11 per cent of GDP, 9 per cent of employment and 65 per cent of the value of exports. By 1990 this proportion had fallen to 6 per cent of the population involved in the production of 4 per cent of GDP and 27 per cent of exports. The picture is compounded by the falling price of rural commodities. Between 1965 and 1989 the price of oil rose 14 times and the price of gold rose 11 times, but that of meat and wool rose by only 3 times the 1965 price. The value of 1965 wool exports in 1990 dollars would be $6,485 million. The value of wool actually exported in 1990 was $2,861 million.[87] The volume of wool exported in 1965 was also higher at 756 million kilograms compared with 640 million kilograms in 1990.[88]

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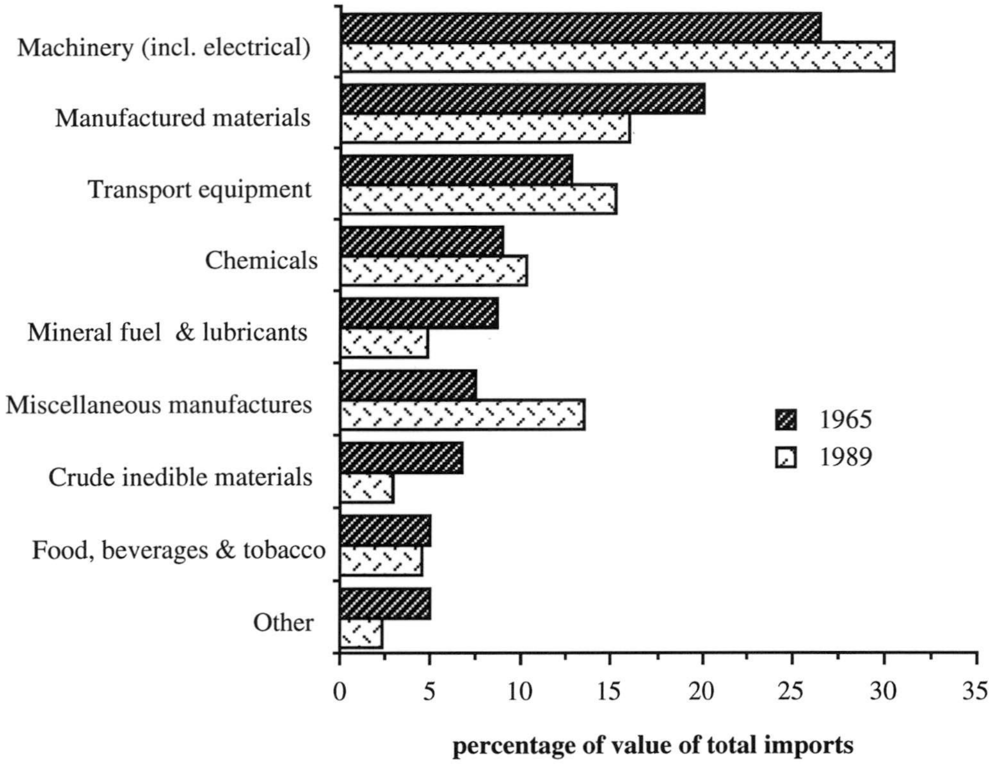
87 In 1990 the wool price was depressed, but in 1988, when the wool price was at its highest level ever at US$11. 65 per kilo, the total value of exports was still only $6261 million.

88 Australian Bureau of Statistics, *Year Book,* no. 53, Commonwealth Bureau of Census and Statistics, 1967, p. 965.
Australian Wool Corporation, *Annual Report 1990-91,* AGPS, Canberra, 1991, p. 23.

Figure 2.3: Australia, the most significant imports by commodity group, percentage of total value, 1965 and 1989



Data source: Foster & Stewart, *Australian Economic Statistics 1949-50 to 1989-90,* p. 13.

There are four categories of goods in which the proportion of imports has fallen since 1965. The decrease in fuel imports is due to the development of an indigenous oil extraction industry. The decreases in manufactured materials, crude, inedible materials and food, beverages and tobacco indicate that some basic manufacturing processes may now be occurring in Australia. The most telling contrast between the nature of imports and exports is that the highest-level categories of imports have a significant value-added component. Australia exports unprocessed or relatively unprocessed commodities and imports from other countries the manufactured goods for necessary for production and lifestyle. Such imports are forming an increasing proportion of Australian exports.

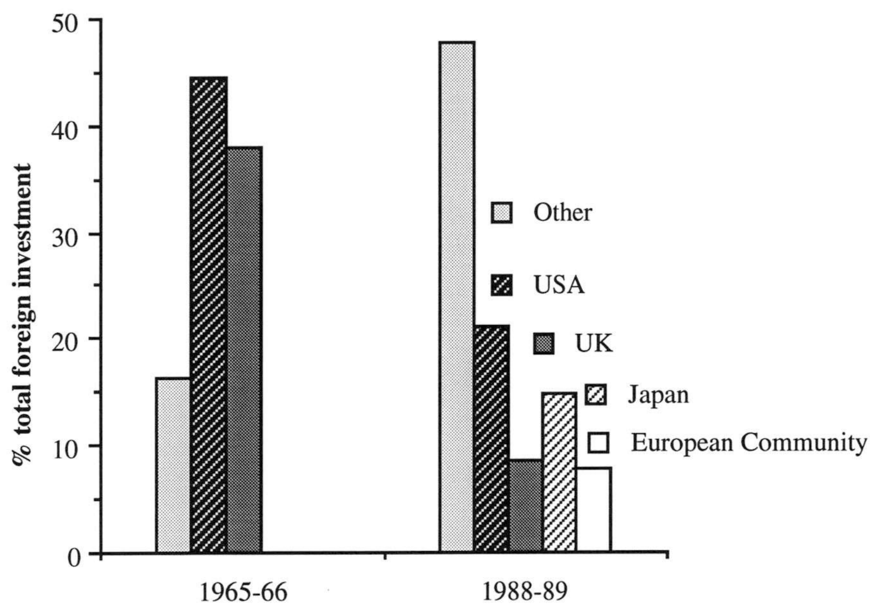
4.1.c Overseas investment in Australia 1965 and 1990

Australia is traditionally dependent on external sources of development capital because of her geographical isolation from the industrially developed countries of the world, the presence of vast mineral resources and large tracts of arable land, and a low level of population to generate capital to exploit these resources have made. At first the foreign capital gained from the export of primary produce was used to buy goods manufactured overseas. Later revenue gained from primary producers provided tariff protection to allow the development of secondary industry in

Australia. There has always been a need in Australia for overseas capital to develop resources, and this has benefited the economy by introducing new industries, new technology and access to overseas markets.

Concern about levels of overseas investment in Australia grew in the mid 1960s and became a bipartisan political issue when McEwen, Leader of the Country Party, and Calwell, ALP leader, advocated regulation of foreign control of Australian industry. The Menzies government commissioned an inquiry on overseas investment by the Committee for Economic Enquiry which found that Australian industry was not overly controlled by foreign companies.[89] Despite this finding consecutive governments have enacted legislation, albeit weak, to maintain minimum levels of Australian ownership in certain industries.[90]

Figure 2.4: Australia: major foreign investors, 1965-88



Data source: Foster & Stewart, *Australian Economic Statistics 1949-50 to 1989-90,* p. 35.

Figure 2.4 compares the major investors in the Australian economy between 1965 and 1988. The figure shows that foreign investment in Australia in 1988 is of more diverse origin than the situation in 1965 when the UK and the USA dominated

89 Committee of Economic Enquiry, *Report 1965*, p. 719.

90 The Whitlam Government instituted formal scrutiny of foreign investment by inter-departmental committees, and the Fraser Government continued the regulation (though not the rhetoric) through the Foreign Investment Review Board which is still extant in 1990. The Hawke Government has relaxed the controls on such industries as oil, gas and banking and exempted from scrutiny the takeover of Australian companies of less than $5 million capitalisation, but has tightened restrictions on the level of foreign ownership in real estate. Between 1986-87 and 1987-88 the number of real estate proposals examined by the Board increased ten-fold. The proposals were worth $9.7 billion of which nearly a third came from Japan.
Foreign Investment Review Board, *Report 1987-88,* Commonwealth of Australia, Canberra, 1989, pp. 13, 14, 31 & 40.

investment. In 1988 nearly 50 per cent of total foreign investment came from multiple sources. Foreign ownership of Australian industry varies according to industrial sector.[91]

The high levels of foreign ownership in manufacturing coincide with the low levels of privately-funded research and development in this sector. In 1985-86 only 31 per cent of research and development in Australia was funded by private enterprise. Half this research takes place in multinational companies which are foreign owned or controlled. Nevile states:

> About 40 per cent of foreign controlled firms undertaking R&D in Australia have controls from overseas on R&D expenditure, and other foreign firms may be discouraged or prevented from undertaking any R&D at all. Local subsidiaries of foreign firms may have access to R&D done overseas, but they may be restricted in the types of products they can produce in Australia and what they can export.[92]

The implications for scientific activity in Australia of the degree of foreign ownership in critical sections of Australian industry are not clear. The Department of Industry, Technology and Commerce, in the 1992 *Australian Science and Innovation Resources Brief,* reports that a low level of research and development expenditure by private enterprise in Australia has traditionally been linked to the high level of foreign ownership in large companies, particularly in the manufacturing industries. The link is sustained by the fact that the increasing levels of research and development by private enterprise in the late 1980s is mainly associated with small, Australian-owned firms.[93]

4.2 The need for restructuring

As traditional commodity-based markets disappear through greater competition and protectionism the structure of Australian economic production will need to widen to fit changing markets. The Australian attitude to technology and its impact on exports can partly be explained by the fact that discoveries of new sources of commodities have in the past allowed policy-makers the luxury of being able to avoid politically unpopular industrial re-structuring decisions. In the late 1960s the mineral boom financed the infrastructure necessary for a growing population, and the oil and gas discoveries of the late 1970s balanced falling manufacturing exports.

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91 Nearly all agricultural industry is Australian-owned with only 2 per cent of activity and 6 per cent of agricultural land under foreign ownership. Similarly, the transport industry is 95 per cent Australia-owned. The highest levels of foreign ownership are found in the mining industry where only 55 per cent is Australian-owned. In the service sector foreign interests own 40 per cent of the life insurance, 34 per cent of general insurance, 35 per cent of registered financial corporations but only 21 per cent of banks. The manufacturing industry is 33 per cent foreign-owned.
Australian Bureau of Statistics, *Foreign Investment Australia 1989-90,* Catalogue no. 5305.0, AGPS, Canberra, 1990, p. 21.

92 Nevile, *The Disaster of Private Sector Research and Development in Australia,* p. 6.

93 Department of Industry, Technology and Commerce, *Australian Science and Innovation Resources Brief 1992,* AGPS, Canberra, 1992, p. 14.

In 1987-88 primary commodity prices rose by 45 per cent and eliminated the current account deficit. In 1985 the OECD Examiners wrote in a report:

> We were struck by what seemed to be a widespread Australian view of technology as in some sense external to national life. This is in part, no doubt, a consequence of Australia's historical idiosyncrasies. A high proportion of the techniques used in Australian industry (although not in agriculture) are indeed imported from overseas, mostly by foreign owned companies. Australia has a tradition of importing technical and professional workers, rather than (or as well as) educating them from childhood. ...The process of technological development is seen as discontinuous: the transition from research to design of a product or service, or from design to sales, seems sometimes to involve the collision of mutually uncomprehending cultures.
> ...The somewhat remote Australian attitude to technology seemed to us to lead to a consistent undervaluation (and to some extent also a misinterpretation) of national technological achievements and possibilities.[94]

In the 1980s Australia has increasingly been experiencing the economic effects of a technological balance-of-payments deficit. In 1990 the OECD commented:

> Countries like Australia, where exports are concentrated in primary commodities and imports are mainly manufactured goods, exhibit greater terms-of-trade volatility than industrial countries where the composition of their exports and imports is similar.[95]

The cause of this volatility lies in the changing composition of world markets. Figure 2.5 compares the situation between 1964 and 1987.

In 1964 the type of export produced by Australia (food and raw materials) accounted for 36 per cent of total global imports. In 1987 this proportion had fallen to 16 per cent. At the same time the proportion of world imports filled by manufactured goods increased from 54 per cent to 73 per cent. In 1987 only 34 per cent of Australian exports were manufactured goods. The situation is worse for advanced manufactured goods, or goods with a considerable component of high technology. In 1974-75 the net balance of the value of exports in this area was minus $6 billion (in 1984-85 constant prices). In 1988-89 the net balance was minus $19.5 billion. In the two years between 1986 and 1988 the deficit increased by a massive 72 per cent. The need for restructuring can therefore be expressed in the following way.[96]

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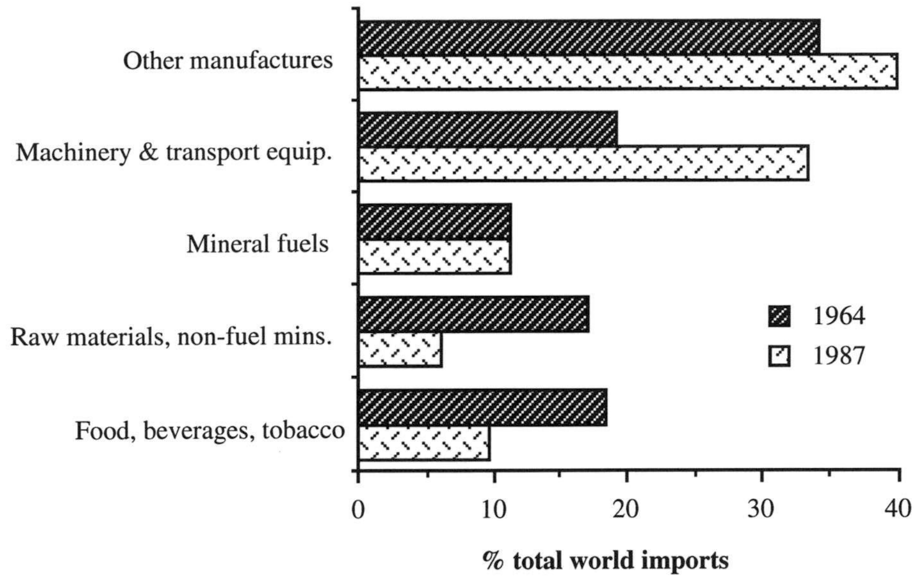
94 OECD, *Reviews of National Science and Technology Policy: Australia,* OECD, Paris, 1986, p. 13.

95 OECD, *OECD Economic Surveys: Australia,* OECD, 1990, p.44.

96 Peter Sheehan, 'Science and Economic Development: A National Challenge', *Canberra Bulletin of Public Administration,* no. 68, March 1992, pp. 132-137, pp. 132-134.

Figure 2.5 The structure of world imports, 1964 and 1987



Data source: Peter Sheehan, 'Science and Economic Development: A National Challenge', *Canberra Bulletin of Public Administration,* No. 68, March 1992, pp. 132-137, p. 132.

Australia exports raw materials or basic manufactured goods which compete in a shrinking market of falling prices. Global wealth is increasingly gained through advanced manufactures which are imported into Australia causing an ever-increasing deficit in terms of trade balance. The problem is compounded by the fact that global markets in advanced manufactures are becoming monopolised by inter-country agreements between transnational corporations and host governments. In such countries as Japan, the UK, Sweden, the Netherlands and the USA, industry and science and technology policies are being influenced by firms agreeing to offset the costs of high technology products by using indigenously-produced components. This cartelisation of the advanced manufactures global market is very hard to penetrate for countries like Australia, who have lagged behind in high technology production. The evidence is that the most knowledge-intensive part of manufacturing is undertaken in the home-base country of transnational corporations.[97] In order to decrease the economic impact of the falling value of exports it is considered necessary to develop 'home-base', high technology industries in Australia. Such industries are dependent on scientific knowledge. The need for industrial re-structuring has made science and technology policy increasingly central to Australia's economic well being. This centrality challenges the autonomy of the science system by replacing scientific objectives with government-imposed socio-economic objectives.

97 Jenny Stewart, 'Science, Technology and Industry Policy: Are We in the Race?', in *Federalism and Public Policy: the Management of Science and Technology,* Federalism Research Centre, Canberra, 1992, pp. 87-98, p. 90.

SUMMARY

This chapter has described the institutional, ideological and economic context of the science policy community in Australia. The picture which has emerged is one of the replacement of conservatism and nationalism by techno-economism in the way in which governments perceive the production of scientific knowledge. The change has occurred as traditional markets for Australian commodities have disappeared and as technological change has transformed the composition of world trade. In the face of declining resources for research the objectives for science policy have become economic rather than cultural. This has resulted in a demand by the executive core and Parliament for increased accountability in the science system. Changing objectives for science have resulted in a reorganisation of the way in which scientific knowledge is produced in Australia. This has been achieved through changing the ideas, rules, and resources about science and allocated to science. The following chapters document and analyse these changes.

CHAPTER 3

CHANGES IN THE ORIENTATION OF SCIENCE POLICY

The key concepts outlined in chapter one contain two references to the importance of ideas in policy action. One is Clegg's notion that control over ideas, often expressed as 'techniques of production and discipline' is an integral part of the exercise of power in social contexts.[1] The other is Atkinson and Coleman's suggestion that one of the key areas to be developed in the policy community approach is analysis of the way in which ideas inform action in policy communities.[2] This chapter seeks to bring together these two notions by examining the changing ideas through which the ideologies described in chapters one and two achieve action and outcomes. It also addresses the question of how such ideas can be obstructed by members of the policy community whose interests are threatened by the proposed changes.

The chapter begins by specifying two sets of ideas: ideas developed by political actors and ideas developed by scientists. Each of these idea sets focuses on two issues: the aims or objectives to which research and development should be directed; and the way in which scientific work should be organised in order to achieve them. The chapter indicates that the origins of these ideas lie in debates about science policy within international contexts. It shows that the political debate about the objectives of science was a confrontation between three positions: the mainstream economic view that state investment in science can lead to growth; the neoclassical economic view that scientific discovery should be governed only by market forces; and the political-economic view that scientific discovery is not related to general well-being but to the interests of particular groups. In each case it shows the ways in which these positions were introduced to the Australian context by key interlocutors. It also argues that a significant formal channel for the introduction of new ideas was the OECD.

The chapter then moves on to examine ideas about the organisation of scientific activity. It shows that there was a general shift in such ideas from a stress on scientific autonomy in the direction of calls for accountability and direct linkage to political objectives. Again it shows the ways in which models of scientific activity developed internationally were introduced into the Australian context by key actors. The chapter concludes by showing how these two sets of changing ideas were adopted or adapted in the four main sectors of science policy under consideration here: higher education research, CSIRO, research in manufacturing and rural industry research.

The capacity to influence policy can be exercised through the development of ideas about the way in which policy is formulated, evaluated and implemented.

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1 Clegg, *Frameworks of Power,* p. 209.

2 Atkinson & Coleman, 'Policy Networks, Policy Communities and the Problems of Governance', p. 167.

Scientific and political ideologies were discussed in chapters one and two. Scientific ideology consists of the norms and values which guide the action of scientists in the production of scientific knowledge. Such values and norms can give little guidance as to the way in which such knowledge should be used socially. Political ideology affords broad views about the way the world should be but does not always offer detailed plans for policy-making. Change in policy arenas is effected both ideologically and ideationally. Change needs the dynamic of political will which comes from ideology, that is to say, certain beliefs about the way the world should be. Change also needs ideas about how broad values and interests can be realised in action.

Members of a policy community derive ideas about policy formulation, evaluation and implementation from a variety of sources. In many policy arenas clear-cut alternatives about the way in which public resources should or should not be used emerge and are debated in public. Only recently has this occurred in the science policy community. The use of scientific knowledge becomes a political issue only rarely and therefore alternative ideas about its use have not been widely debated outside the science policy community. Until recently such discourse was cursory but as the availability of public resources stabilises or diminishes, and as scientific knowledge is perceived as being of critical importance economically, the debate becomes more openly and intensely argued. This chapter discusses the ideas used by opposing interests in the science policy community to justify their control over the organisations and resources of scientific production.

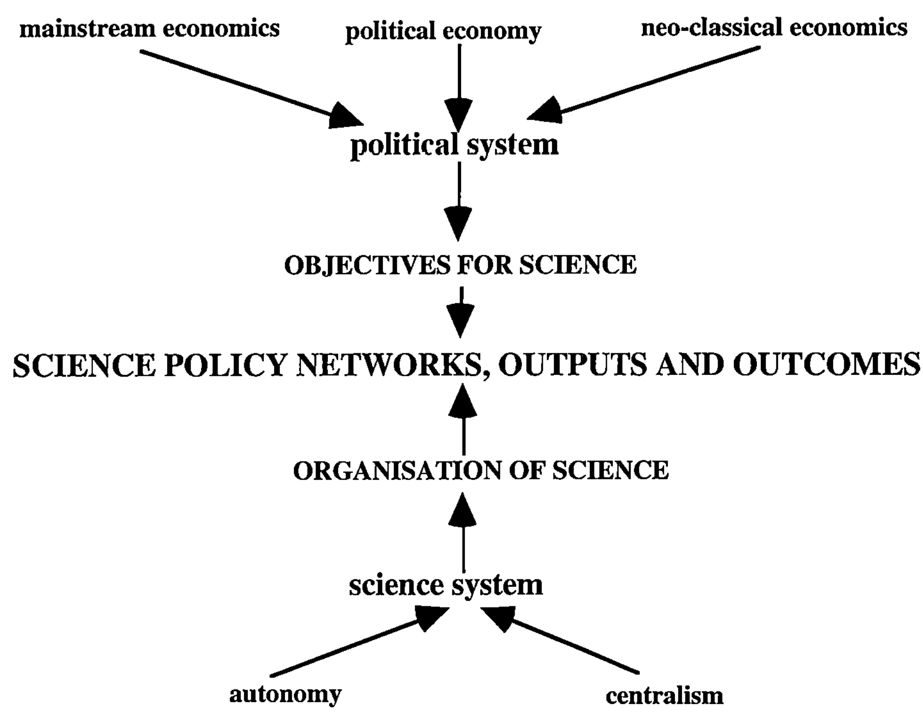
The general thrust of the argument is that the debates emerged internationally, were carried into the Australian context both through the formal action of the OECD and by internal contacts, and were here resolved in terms that moved the orientation of science policy away from a concentration on preserving scientific elitism and autonomy towards techno-economistic goals of the application of research to economic production.

1. Two Sets of Ideas

Ideas informing science policy can be broadly categorised into two sets which correspond analytically with, on one hand, action in the political system and, on the other, action in the science system. Action in the political system centres around the authoritative allocation of values. The predominant ideas underlying the allocation of values in science policy have come from economics and political economy. They involve questions about the way in which public financial resources are allocated to the production of scientific knowledge, and about who controls the allocation of such resources. Some ideas argue that market forces should be allowed to direct the flow of financial and other resources to the production of scientific knowledge. Others maintain that government intervention is necessary to fund areas of research which are perceived to be vital to society but in which markets show little interest.

Action in the science system centres on the production of scientific knowledge. Ideas about the way in which production is organised can be grouped into those advocating autonomy for scientists in the way they undertake their research; and those which argue that some measure of political control is necessary when public resources are being used to fund the production of knowledge, and when the application of such knowledge has social and economic consequences beyond the control of scientists. Figure 4.1 summarises the categorisations which are used in this chapter to identify the origin of the ideas and the way in which they have been articulated in Australia.

Figure 4.1: The origins of ideas informing science policy



2. Objectives for Science

Political awareness of the link between science, technology and economic production emerged when the demand for an increasing rate of innovation in industry exceeded the capacity of the non-academic engineer to devise new processes. It occurred first at the turn of the century in Germany which did not have Britain's large 'captive' colonial market and needed more advanced and rapid production in order to compete.[3] The link was reinforced after the Second World War when, in 1945, Vannevar Bush and other scientists reported to the Eisenhower Government in the USA that the allocation of public resources to science, which had proved a successful policy in achieving military superiority, could equally well be successful in maintaining economic superiority.

3 Rose & Rose, *Science and Society,* p. 25.

The US government accepted the findings and conditions of Bush's report and his success in convincing the US Government to continue national science funding inspired natural and political scientists in other advanced western economies to proselytise similar ideas to their governments.[4] Analysts specialising in science policy came mainly from two academic disciplines: economics and political economy. The following section discusses the development of such ideas about science policy. The adoption and adaptation of these ideas by the Australian science policy community is then examined.

2.1. Ideas from economics

There are two main schools of economic thought that have influenced science policy: mainstream economics which argues that governments should invest in research and development in order to stimulate economic growth; and neo-classical economics which argues that such stimulation should come directly from market forces.

2.1.a Mainstream economics

In the 1950s and 1960s economic theorists 'discovered' science and technology. Having previously consigned the effects of technology to a residual category of non-economic factors in national growth, theorists began to need to explain the lack of fit between theory and experience. Freeman, the first Director of the Science Policy Research Unit at Sussex University, asserts:

> ... a plausible case can be made for the view that one of the important reasons for the world-wide economic growth rate in the 1950s and 1960s being higher than in any previous quarter century was the high rate of technical change sustained by the massive expansion of R&D, especially in manufacturing industry.[5]

According to Freeman the mechanism for innovation in industry is now the science laboratory rather than the technically developed machine. Modern science needs resources beyond the level of small firms and most innovation now occurs in large-scale organisations. This means that governments must often underwrite high risk research and development in which even large firms are not prepared to invest.[6]

Quantitiative studies of the effects of technological change on economic growth were performed to validate the theories. These studies used such indicators as patent statistics, product aggregate functions and case studies of innovations. Solow, for instance, claimed that technological change accounted for 87 per cent of economic

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4 Vannevar Bush, *Science - The Endless Frontier,* US Government Printing Office, Washington, 1945.

5 Christopher Freeman, *The Economics of Industrial Innovation,* The MIT Press, Cambridge, Massachusetts, 1982, p. 196.

6 Christopher Freeman, 'Economics of Research and Development, in *Science, Technology and Society,* eds. Ina Spiegel-Rösing & Derek de Solla Price, Sage London, 1977, pp. 223-275, pp.254-255.

growth in the USA between 1904 and 1949.[7] Most studies assumed a linear sequential model of the translation of scientific knowledge into goods and services, that is, that there is a sequence of cause and effect events through time, the first events leading to subsequent events. Layton categorises these models as being either 'discovery - push' in which new or existing scientific knowledge leads to innovation; or 'demand - pull' in which factors of production external to the scientific community solicit new scientific knowledge in the process of developing new goods and services.[8]

In 1957 the launch of Sputnik by the USSR provoked a debate in the USA about the adequacy of resource allocation to basic science. As part of the discussion Nelson, an economist with the Rand Corporation, wrote what was to become a seminal paper for mainstream economic theory entitled *The Simple Economics of Basic Scientific Research.*[9] In the paper Nelson considers the question of what the optimal resource allocation to basic science should be in a national economy based on free enterprise.

According to Nelson private firms will normally undertake or sponsor applied research which will reduce production costs or improve the finished product or process and thereby increase market share. Investment in research and development will proceed only to the point at which research costs outweigh expected private gains.[10] Few advanced breakthroughs will occur in applied science because the costs of conducting such research over the time necessary to achieve sufficient knowledge in a particular research area will not be appropriable through the market. Also, not all knowledge created by basic research is patentable and its dissemination will cause external economies which cannot be captured in market prices.[11] Firms undertaking basic research which yields results which they cannot exploit commercially, but which could be used by other firms, will prevent the dissemination of that knowledge on the grounds of inappropriability. However, advances in basic research are often of great social value, defined by Nelson as: '... a given flow, over time, of benefits that would not have been created had none of our resources been directed to basic research'. Social value must be weighed against the social cost of forgoing the benefits of allocating the resources elswhere than to basic science.[12]

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7 R. M. Solow, 'Technical Change and the Aggregate Production Function', *Review of Economics and Statistics,* August 1957, pp. 312-320.

8 Layton claims that this oversimplification of the relationship between the production of scientific knowledge and economic production has resulted in many fallacies in science policy which are hard to eradicate. It is more useful to think of the relationship as a 'branching network of interacting events' in which there is no attempt to identify temporal antecedence.
E. Layton, 'Conditions of Technological Development', in *Science, Technology and Society,* eds. Ina Spiegel-Rösing & Derek de Solla Price, Sage London, 1977, pp.197-222, pp. 203-5.

9 Richard R. Nelson, 'The Simple Economics of Basic Scientific Research', *Journal of Political Economy,* vol. 67, no. 3, 1959, pp. 297-306.

10 Ibid., p. 301.

11 Ibid., p. 302.

12 Ibid., p. 297-298.

Nelson argues that the most efficient way of doing this is to ensure that basic research is undertaken in institutions organised around the principle of the rapid dissemination of research results to the greatest number of firms capable of exploiting the findings. In this way a society obtains the maximum benefit. Such institutions may be universities or industry associations sharing the costs of research which will yield benefits to all members. He concludes that universities are the most efficient form of organisation for the production of basic science because researchers have a deep knowledge of their particular research areas, and are therefore more aware of where breakthroughs can best be commercially exploited.[13] It would be socially inefficient for such researchers to be tied to the conditions of secrecy needed to realise profits in the market.

2.1.b Neoclassical economics

Other writers began to reiterate the theories of classical market economists and advocate minimal government intervention in the relationship between research and development and market needs for innovation. Williams challenged the notion that, despite the enormous impact of research and development on agriculture and industry, increasing expenditure on research and development would automatically increase national economic growth. Factors which intervened in the relationship were:

- some research is undertaken for purely scientific reasons and therefore should be considered as economic consumption rather than production;
- not all research results are commercially developed;
- there is little interaction between scientists and the world of commerce: businessmen do not always know what to do with research results and scientists do not always produce research which can be exploited commercially;
- research results and technological know-how move easily and cheaply between countries and are therefore difficult to evaluate in national cost benefit terms.[14]

Williams said that there was a greater opportunity for countries at a low level of technology to grow by using technology developed elsewhere. In mission-oriented research and development, governments (or firms) could easily calculate the benefits of investing in new science production by:

- calculating the present costs of inventing and installing the new process;
- calculating the present value of money benefits expected to accrue;
- establishing where the expected benefits exceed the expected costs.[15]

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[13] Ibid., p. 306.

[14] Professor Williams had previously been at the Manchester School of Social and Economic Studies where there was a developing interest in science policy in the early 1960s. He co-authored with C.F. Carter a seminal paper entitled 'Government Scientific Policy and the growth of the British Economy'.
B.R. Williams, 'Economic Appraisal of National Research and Development Problems', *Australian Journal of Science,* vol. 31, no. 6, 1969-70, pp. 203-205, p. 204.

[15] Ibid., p. 205.

He asserted that, where segregation of research and development is not efficient (as in manufacturing), there needs to be a drastic re-structuring of industry.

Kealey adopts a similar neo-classical approach to the use of government funds for science but argues against the production of basic research in universities. The justification for such funding is post hoc and opportunistic.[16] He claims that the establishment of university research follows rather than precedes national economic growth. Defending his argument he cites the examples of the establishment of the British civic universtites in the mid- to late-nineteenth century when economic power had already begun to shift to Germany; and the more recent case of Japan where economic growth was effected using 'borrowed' technology and where basic research has increased in universities only in the late 1980s.[17] Kealey advocates that medium-sized industrial countries should concentrate on creating applied scientific knowledge. University science should be funded only to the extent of retaining scientists of sufficient calibre to train new researchers for industry. If no outside sponsor can be found to fund a researcher's work then governments must step in to prevent the researcher from leaving the higher education system. This reasoning has certainly not been applied in Australia where the higher education science subsystem is increasingly seen as the cradle of future economic development.

Kealey also advocates a market-centred approach to such areas as environmental research which, in Australia, has always been considered as a public good. He claims that if groups were able to allocate individually the distribution of their taxes currently spent on the science system in general they could sponsor the research most suited to their interests. This close association between the providers and users of research funds would ensure a much more efficient use of resources. Kealey's views have not been widely adopted in the UK. He reports that for a short time, in 1989, his ideas were 'adopted' by the Conservative Party and published by a right wing political 'think tank', but that since then his ideas have been abandoned as too radical in the face of opposition from fellow-scientists.[18]

2.1.c Mainstream and neo-classical economics in Australia

In Australia economists were slow to pick up the concept of science-based innovation as being of relevance to the Australian economy. In 1965 four top economists gave keynote lectures on Australia's economic future at the 1965-66 ANZAAS Congress. None of them mentioned the contribution of research and development to national economic production.[19] In the same year the Vernon Committee devoted a whole

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16 Terence Kealey, *Science Fiction - and the true way to save British science,* Policy Study no. 5, Centre for Policy Studies, London, 1989, p. 30.

17 Ibid., p. 24.

18 Terence Kealey, Department of Clinical Biochemistry, Addenbrooke's Hospital, Cambridge, UK. Interview, 9.7.93.
Kealey is himself a research scientist whose work is sponsored both through the national research system and through private industry funds.

19 They were: W.B. Reddaway, Director, Department of Applied Economics, Cambridge University;

chapter to consideration of the economic impact of research and development and the model used in the report is definitely the mainstream economic model that governments should stimulate economic growth by subsidising industrial investment in reseach and development.[20] The authors considered the costs and benefits of importing technological know-how and found firmly in favour of increasing government subsidies to research and development.

In general economic models of research and development in Australia have tried to combine elements of both schools of thought. In 1968 Williams, who had by then moved from Manchester to Sydney University, was invited to address The Australian Academy of Science (AAS) at its first Symposium on Science, Technology and Society (the forerunner of the influential Science and Technology Forum).

Williams repeated his ideas at intervals over the next twenty years. In 1972 he addressed a forum entitled 'Science Policy for Australia' organised by the Australian Industry Research Group (AIRG). He reiterated his hypothesis that such science as basic, medical and environmental research is consumption-oriented and should therefore be funded according to broadly-defined social objectives. He contrasted this with industrial research and development which is funded in order to make profits. The role of government, and therefore of science policy, is to identify where incongruities exist between innovative opportunity and industrial structure and to develop programs which will realign scientific output and industry needs.[21]

In 1982 Williams assessed the effects of research and development on recession economics and concluded that the forecasts of the 1960s had been too optimistic in the face of such other factors as: oil price rises; high wage growth rates and consequent cost inflation; declining profits, devaluation of the US dollar; and the changing management of demand. The consequence for governments in formulating science policy is to fund only those projects for research and development for which there are known benefits in terms of production and marketing requirements. This process of picking winners requires a more sophisticated approach than simply increasing research and development expenditure.[22]

Sir Leslie Melville, Australian National University, member of the Vernon Committee;
Professor H. W. Arndt, Australian National University;
Professor F.W. Holmes, University of Wellington, New Zealand.
Australian Journal of Science, vol. 28, 1965 & vol. 29, 1966.

20 Although the issue of research and development was not included in the terms of reference of the Enquiry, the Committee considered that consideration of its economic impact was essential because of the relevance of research and development to productivity.
Committee of Economic Enquiry, *Report, May 1965,* p. 418.

21 Bruce Williams, 'Science policy for Australia', *Search,* vol. 3, no. 6, June 1972, pp. 205-209, p. 206.

22 Bruce Williams, 'Economic Impact of Science and Technology in Historical Perspective', *Minerva,* vol. XX, nos. 3-4, Autumn-Winter 1982, pp. 301-313, p. 308.

2.1.d Johnston and ambiguous ideas about market failure

One economist who advocated continuing government intervention was Johnston who had also worked in the Manchester Centre for Social and Technology Policy. In 1979 Johnston, then at the Centre for Technological and Social Change at Wollongong, was co-opted by the Fraser Government to write the first Science and Technology Statement, and his influence has persisted throughout the ALP Governments of the 1980s and 1990s. Johnston argued in 1982 that the Australian science system should merit special consideration because of four special characteristics:

- the system was too oriented to rural interests;
- manufacturing industry had a poor tradition of innovation;
- the sectors of the science system were too rigidly separated to allow ideas and human resources to cross boundaries;
- the federal political system had resulted in a decentralised form of decision-making for science policy and this, combined with an anti-intellectual bias in the political system meant that expertise was at best fragmented and distrusted.

It would therefore be disastrous for science policy in Australia if, at a time when a set of machinery for science policy had finally been established, government economic, industrial and social policy was to be dictated purely on market principles with minimal government intervention.[23]

Normally, Johnston says, the concept of market failure is used to argue *for* government intervention in science and technology policy. It is argued that private investment in research and development declines because the benefits (and costs) which accrue to private investors does not accord with social benefits. The sources of market failure for scientific research are said to be indivisability (where individual firms do not have the resources or skills to set up facilities); inappropriability (when the firm originating research cannot appropriate all the benefits which eventuate); uncertainty (the threat to profitability of high risk activity); lack of property rights in potential inventions (because no-one owns undiscovered knowledge it has no known market value to guide firms in their investment in research); lack of management expertise in judging the marketability of scientific products; external health and safety costs; lack of economic incentives, and reluctance to invest in long-term projects. Although the premises of market failure have been challenged, it remains one of the most frequently used economic rationales for increased government investment in science. According to the theory, governments are supposed to support science up to the point at which social costs are outweighed by private benefits.[24]

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23 Ron Johnston, 'Australian Science Policy: Now we can steer, where do we want to go?', *Current Affairs Bulletin,* vol. 59, no. 3, August 1982, pp. 20-30, p. 22.

24 R.A. Joseph & R. Johnston, 'Market failure and government support for science and technology: economic theory versus political practice', *Prometheus,* vol. 3, no. 1, June 1985, pp. 138-155, pp. 139-142.

In Australia however, Johnston claims that the concept of market failure is often used by economic rationalists *against* governments intervening. He cites the instance in 1981 when the Industries Assistance Commission, the Department of Finance and the Treasury argued *against* government support for science on the grounds that it was impossible to measure the point at which social costs costs and private costs diverge. At the same time the Department of Science and Technology used the concept to argue *for* government intervention.[25] Johnston interprets this contradiction as being due to the fact that political choices require difficult value judgements about why one policy is preferred to another. If an argument against a policy choice can be couched in economic terms it can be rejected on the grounds of inefficient use of public funds, thereby avoiding electorally damaging value judgements.

The implication for science policy, says Johnston, is that issues cast in market failure terms tend to be grossly oversimplified which leads governments to look for easy economic solutions to science policy problems, when in fact complex interorganisational solutions involving the exercise of political judgement are required:

> Consequently, policy is not considered in terms of what might improve an already complex regime, but tends to revert to comparing admittedly imperfect intervention to stylised perfect markets.[26]

It is interesting that few actors in the science policy community in Australia have developed a more explicitly market-centred science policy such as the one advocated in the UK by Kealey.[27] There are few suggestions that, for example, CSIRO should be totally privatised, or that universities should concentrate solely on basic research and leave applied research to market demand. A nationalistic ideology towards science, which sees a science system as a symbol of national maturity not necessarily connected with economic production, combined with a conservative ideology which allows the science system autonomy in deciding objectives, and the lack of innovative culture in manufacturing industries has led to a traditional dependence on governments and scientists rather than markets to manage the science policy community.

2.2 Ideas from political economy

Some writers on science policy adopt an approach which explicitly examines the relationship between the production of scientific knowledge, economic production and the distribution and exercise of power in society. One of the first to do so was Bernal who argued that the domination of economic production is an important factor in deciding the direction and beneficiaries of the production of scientific knowledge. In 1939 he outlined a method of organising research which would benefit society as a whole rather than entrepreneurs alone. A collective fund, formed by the contributions

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[25] Ibid., pp. 144-147.

[26] Ibid., p. 152.

[27] The exception to this is Roach of the Sydney Business and Technology Centre whose ideas are discussed in section 4.3 below.

of civil, military and private institutions, and administered by a science and industry council, would be used to finance a mobile army of scientists organised on the basis of voluntary association to work on projects decided by representatives of the national economy.[28]

Bernal's ideas were idealistic and strongly influenced by the conduct of research in the USSR. However, his basic thesis was used by Hilary and Steven Rose, though their analysis of political ideology is less tinged with socialist idealism than Bernal's. They reject the writings on science policy which came out of the USA in the early 1960s as: '...liberal responses lacking a clear theoretical understanding of the relations of science to capitalist production'.[29] They claim that the political ideology of techno-economism has captured the production of scientific knowledge in both capitalist and socialist countries. The 'interpenetration of science and society', whereby scientific knowledge permeates every facet of social existence, has meant that the interaction beween governments and scientific communities has also changed. Concepts of competition, elitisim and a 'natural' form of society in accord with the laws of nature can be used to legitimate political actions. Consequently governments and their 'industrial counterparts' cannot allow the scientific community to remain autonomous. The production of scientific knowledge has a deliberate social purpose which cannot be defined by scientists. Policy decisions must therefore be made outside the scientific community.[30]

In the early 1960s, in the UK, Sir Solly Zuckerman was one of Harold Wilson's principal scientific advisers. He was also the Scientific Adviser to Lord Mountbatten and the Department of Defence. In 1961 he produced a report entitled *The Management and Control of Research and Development* which provided the definitive thinking on the categorisation of scientific knowledge production until the publication of the Rothschild Report in 1971.[31] Zuckerman was unambiguous in his objectives for research. His philosophy for the production of scientific knowledge was that it is the essential base for industrial growth and economic welfare. He states:

> The primary purpose of the research and development which is carried out by, or for, manufacturing industry is not to increase the body of scientific knowledge, but to secure and maintain a high rate of productivity through technical innovation, to develop new products, and eventually to make greater profits.[32]

In discussing the criteria for science policy, Zuckerman emphasises that the allocation of funds for scientific research should be judged not only according to technical feasibility but also after an appraisal of the costs of a project, its expected financial

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28 J.D. Bernal, *The Social Function of Science,* George Routledge, London 1939, pp. 266-319.
29 Rose & Rose, *The Political Economy of Science and Technology,* p. 17.
30 Ibid., p. 23.
31 Sir Solly Zuckerman, *The Management and Control of Research and Development,* HMSO, London, 1961.
32 Sir Solly Zuckerman, *Beyond the Ivory Tower,* Weidenfeld & Nicholson, London 1970, p. 119.

benefits and its impact on the national balance of payments. However, it is not high quality research alone which seeds economic growth. There must also be competent industrial processes of innovation. These include prototype development, tooling, market research and preparatory production.[33]

2.2.a Political economy in Australia

The science policy analyst in Australia who most closely approximates the Roses' approach to the relationship between economic power and science policy is Encel who has used the term 'techno-economism' in relation to the Hawke Government's approach to the direction of research activities.[34] Encel was the first writer to analyse systematically the relationship between governments and the production of scientific knowledge in Australia. He was aware of the international interest in science policy in the 1960s, examined the Australian situation and conducted research into science policy systems in the USA, the USSR, Canada and Britain in an attempt to stimulate serious and formal discussion about the need for a planned science policy in Australia. He saw the relationship between governments and the production of scientific knowledge in Australia in the global economic context of a small country with a dependent economy. The government was therefore faced with the need to make priority choices. Encel was critical of a system of policy advice and decision-making about science which listened only to the views of an elite minority of scientists. What was needed in Australia was an 'appropriate organisation of advice' which would assist governments to keep a balance between funding for universities, government research organisation and incentives for industry.[35]

Encel said that there were ten reasons 'extrinsic' to the practice of science why governments perceived the need to intervene in the production and use of scientific knowledge:

1. science is a major contributor to economic growth;
2. science is a source of national prestige;
3. science is a source of military strength;
4. science is the source of innovation for international competitiveness;
5. science as a means of protection for key industries;
6. science as a means of using natural resources and managing natural problems;
7. science as a source of education and technical human resources;
8. science as the means to better health;
9. science as the solution to technogenic problems such as pollution;
10 science as an integral part of cultural expression.[36]

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33 Ibid., pp. 120 & 153.

34 Sol Encel, 'Is the Development of a Scientific Culture Possible or Appropriate?', Address given to the Public Affairs Conference 'Science and Society', Australian National University, 7-9 June, 1989.

35 Encel, S.,'Science and Government Policy', *Public Administration,* (Sydney), vol. XXIV, no. 2, June 1965, pp. 104-116, p. 106.

36 Encel, S.,'Science and Government Policy: IV - Australia', *Public Administration,* (Sydney), vol. XXVII, no. 2, June 1968, pp. 166-193, pp. 169-174.

Encel's discussion of these ten reasons in the context of Australia's economic position in 1968 reveals how the policy orientation has changed in the intervening 25 years. He dismisses the first four reasons as inapplicable to Australia since they apply only to countries with advanced industrial economies with a large military component (this was, however, at a time when 36 per cent of the appropriation budget was devoted to the Weapons Research Establishment). Encel claimed that there was no approbrium attached to importing technology developed overseas. What Australian governments needed to do was to encourage scientists to develop technology unique to the solution and development of Australia's economic and social needs. This required:

- a body of information about research expenditure and activity;
- a science policy agency within the Department of Education and Science;
- a science policy advisory council on the model of the NH&MRC.[37]

Encel was scathing in his attack on the apathy of the Australian conservative governments in dealing with the problem of science policy. He labelled as 'simple-minded' the advice to the government given by the AAS which failed to recognise the complex reciprocity of science and society and the consequent need for the systematic planning of scientific production in Australia.[38] The reaction to these techno-economic proposals by Encel indicates the degree to which government ideas about policy for science in the 1960s in Australia were framed in a very narrow understanding, not only of science, but also of policy. A senior representative of the Department of National Development questioned whether science policy was anything more than the principles upon which research was organised and therefore a matter for each individual scientific organisation.[39]

Zuckerman's ideas were introduced to Australia through the ALP Party Platform in the mid 1960s and later as Gough Whitlam used the lack of a Liberal-Country Party policy on science to further his portrayal of the government as tired and unfitted to the new technological era.[40]

2.3 The influence of the OECD

The OECD has been an important disseminator of these ideas of techno-economism in science policy. There has been a section of the Organisation devoted to the development of science policy issues since its establishment in the early 1960s. The Organisation influences ideas about science policy through its practice of studying

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37 Ibid., pp. 178 & 181.

38 Sol Encel, 'Science, Technology and the Australian Community', *Search,* vol. 1, July 1970, pp. 12-17, p. 14.

39 Ibid., p. 182. Similar advice was obviously given to Gorton by the Department of Education and Science before making his famous 'wheelbarrow pushers' statement.

40 Morrison, Interview, 1.11.89.

national science policy communities and advising member governments on their development.[41]

2.3.a Early OECD ideas on innovation

In 1960 a report was published by the Organisation for European Economic Co-operation (OEEC), the forerunner of the OECD, which emphasised the need for Europe to accelerate the rate of the application of scientific knowledge to production in order to be able to compete on equal economic terms with Russia, the USA and China. The author states:

> The experience of the OEEC over the last ten years has demonstrated the interdependence of the European economies and the growing relative importance of intra-European trade. No country of Western Europe will be able to isolate itself from the effects of a decline in the relative importance of Europe in the world economy....The answer to this threat clearly lies in the more energetic application of science to economic growth.[42]

In the expansionary economic climate of the 1960s such advice was heeded and Europe followed the USA and Russia along the path of spending up to three per cent of GNP on research and development. The OECD advised member governments hoping to emulate the example of the two superpowers. Fears of a 'brain drain' from Europe and political acceptance of the relationship between economic growth and increased scientific output allowed scientists to demand funds from governments at a time of rapid economic growth.[43]

In 1963 the OECD published a report for the first ministerial meeting on science citing studies of capital investment which showed that most of the effect of increased productivity attributed to increased capital investment was in fact due to the technology component of that capital. The new technology, which accounts for rising productivity and the resultant economic growth, emerges from research, invention and development which are themselves in turn the product of education. All research may in time lead to new knowledge which can be used to promote national economic growth. Governments therefore should aim to spend a certain proportion of GNP on research and development.[44]

2.3.b Legitimate intervention

Later the message was broadened to manage the uncertainties about the social uses of scientific knowledge which arose in the 1960s. Industrial pollution, the use of the

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41 Dr Les Rymer, Director, Science and Technology Strategy Section, Department of Industry Technology and Commerce, Canberra, Personal communication, 30.4.90.

42 Dana Wilgress, *Co-operation in Scientific and Technical Research,* Organisation for European Economic Co-operation, n.pp.

43 Jean-Jacques Salomon, 'Science Policy Studies and the Development of Science Policy', in *Science, Technology and Society* eds. Ina Spiegel-Rösing & Derek de Solla Price, Sage London, 1977, pp. 43-70, pp. 53-55.

44 OECD, *Science and Economic Growth,* OECD, Paris, 1963, pp. 17-20.

scientific knowledge generated by the military-industrial complex of the USA in the Vietnam war, the increasing power of multi-national companies vis-à-vis national governments, and the increasing economic and social gap between developed and developing countries raised questions about the validity and morality of policies for science. In 1971 the OECD issued the Brooks Report which argued that science policy is of use to governments in this dilemma because the allocation of resources for the production of scientific knowledge not only means a 'policy for science' but also 'science for policy':

> It includes government encouragement of science and technology as the roots of strategy for industrial development and economic growth; but it also includes the use of science in connection with the problems of the public sector.[45]

Governments should therefore use such knowledge, firstly to influence markets by taxes and subsidies which will produce action towards desirable ends; secondly to regulate economic production in the interests of safety and non-pollution; and thirdly, and perhaps most significantly:

> ...to direct economic activities of governments deemed to be sufficiently in the general public interest to warrant supplementing private activities beyond the level that market forces alone would generate. These interventions will affect the allocation of investments and the direction of innovation.[46]

Although science and technology are still seen as fundamental to economic growth, simply allocating funds to research and development is not enough. In addition, scientific knowledge must be used as both the engine and regulator of economic growth. Sectoral approaches such as that used in the USA, where the allocation of funds for research and development funds is the responsibility of the significant decision-makers of the sectors of for example, health, welfare or agriculture, need to be balanced by centralised decision-making which directly allocates research and development funds to specific activities within sectors.[47]

2.3.c The role of research in industry restructuring

The 'social needs' approach to science policy did not survive the economic and political rigours of the 1970s. The oil crisis and subsequent recessions in industrialised economies forced governments back to the narrower perceptions of innovation directed at economic survival. Advances in computer, biomedical and materials science opened up new avenues of economic production. These changes together critically strengthened the position of political actors advocating greater

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45 The Report was compiled by an Ad Hoc Group on New Concepts of Science Policy, chaired by Harvey Brooks of Harvard University and including Alexander King, the Director-General for Scientific Affairs, OECD, who, in 1974, was one of the Examiners for the first OECD Report on Science and Technology in Australia.
OECD, *Science, Growth and Society,* OECD, Paris 1971, p. 37.

46 Ibid., p. 89.

47 Ibid., p. 92.

government intervention in deciding the direction of scientific research. In 1985 the OECD reported:

> Government priorities for science and technology have changed markedly in recent years. Support has shifted toward industrial innovation, usually at the expense of areas such as the environment, energy and health and social services. Long-term research is being steered to areas that may contribute most to advancing the new technologies, and university/industry co-operation is being fostered for the same purpose.[48]

The OECD perceives a problem arising from the fact that most member countries are concentrating on the same priority areas of research and development. This could lead to overproduction. Governments therefore have to be aware, not only of the strengths and weaknesses of their own research systems and productive forces but also of their position in the global economic and research systems in order to allocate resources to those areas of research most likely to be exploitable and profitable in their own productive context. Not all members have the ability to pursue all the new developments. Governments therefore need to pinpoint certain sectors of industry in which restructuring will be supported by government aid.[49]

The focus of the OECD message has therefore changed considerably over thirty years. In the 1960s broad brush funding was advocated with sectoral interests deciding their own areas of research to be followed. All research and development would eventually lead to innovation and economic growth. This advice was changed in the 1970s to one of expanding the role of scientific knowledge in policy-making. Governments were to engage experts to monitor and regulate economic growth and innovation in the name of social as well as economic needs. In the 1980s science policy entered a climate of expanding scientific knowledge and static or contracting resources. The call for greater intervention in science and technology production now includes restructuring entire industries and the negotiation of science policy issues with multinational corporations.[50]

2.3.d The OECD and Australia

Australia joined the OECD in 1971.[51] One of the services offered by the Organisation to its member countries is a systematic review of scientific activity. The first of these

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48 OECD, *Science and Technology Policy Outlook 1985,* OECD, Paris, 1985, p. 8.

49 Ibid., p. 12.

50 Ibid., p. 10.

51 Curiously, this event of some significance was not acknowledged publicly by the Gorton Government. It required a Parliamentary question upon notice in December 1971 from the Deputy Leader of the Opposition, Lance Barnard, to the then Minister for Education and Science, Malcolm Fraser, who answered that Australia had in fact joined the OECD in June 1971. The reason for the lack of publicity was hinted at in April 1972 when Al Grassby asked Prime Minister McMahon whether the OECD was about to undertake a survey of the Australian economy. McMahon replied that the Australian people, and not the OECD should be the judges of the Australian economy.

Australia: House of Representatives 1971, *Debates,* vol. HR 72, pp.2330-31;
House of Representatives 1971, *Debates,* vol. HR 75, p.4582;

was requested by Morrison, Minister for Science and Consumer Affairs in the first Whitlam government, and undertaken in 1974. The resulting Examiners' Report found that the production of scientific knowledge in Australia required: '...more coherent statements of policy, closer articulation with national economic and social policy considerations and closer working with universities and industry'.[52] Eleven years later the message was the same. In 1985 the OECD Examiners reported that, in Australia, the process of research and development was discontinuous with the design and production of new goods and services.[53]

Policy networking with the OECD occurs through the exchange of personnel and through attendance at OECD Science and Technology Secretariat meetings which perpetuate and redefine the OECD ideology. For example John Bell, (now Secretary of the Department of Industry, Technology and Regional Development), was at one time head of the OECD Science and Technology Secretariat in Paris.[54]

Summary: Ideas about Objectives for Science in Australia

In the mid 1960s techno-economistic ideas about government objectives for science were developing in the USA and in Europe. Economic thought in Australia was slow to incorporate these ideas about the relationship between wealth generation and research and technology into their plans for Australia's economic future. The ideas were first propagated in Australia by Encel (a political economist) and Williams who had undertaken science policy research in one of the foremost centres in the UK. Encel's ideas were repudiated by senior public servants in non-science portfolios who maintained the conservative position of the autonomy of scientists in deciding objectives for science.

The ideas gained some currency when they were adopted by Whitlam as part of his long campaign for government culminating in the 1972 electoral victory. However, the political will of the Whitlam government to institutionalise the proposed changes proved ephemeral (these changes will be discussed in chapter four). The ideas were restated more forcefully as global economic factors and Australia's deteriorating position in the global economy forced the Fraser government to call for new ideas about how to harness publicly-funded research and development more closely to economic production. The ideas were finally fully adopted when the political will of the Hawke government was applied to the techno-economistic ideas about the organisation of science as articulated by the OECD and by economists in

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House of Representatives 1972, *Debates,* vol. HR 77, pp.1778-79;
House of Representatives 1972, *Debates,* vol. HR 78, pp. 3416-17;
House of Representatives 1972, *Debates,* vol. HR 80, pp.1819-20.

52 OECD, Examiner's Report on Science and Technology in Australia, AGPS, Canberra, 1974.

53 OECD, *Reviews of National Science and Technology Policy: Australia,* p. 13.

54 John Bell & Allan Aird, *Science Policy in Practice,* Paper presented to the Science and Society Conference, Australian National University, 7-9 June 1989.

Australia who had by then developed systematic ideas about the relationship of research and technology and economic growth.

3. THE ORGANISATION OF SCIENCE

Ideas about the way in which the production of scientific knowledge is organised are central to government objectives for the research system. The relationship between the interests of governments and those of science were discussed in chapter two. However, the exchange relationship is not unproblematic and both sides have expectations which may be mutually antagonistic. When governments' expectations of the scientific community are directed towards cultural or nationalistic objectives then scientists are usually allowed to decide the course and content of research. Scientists, particularly those working in the public sector, traditionally demand autonomy in the way in which they select and organise their work. The acceptance by Eisenhower of Vannevar Bush's 1945 recommendations included the condition of scientists' autonomy. This further legitimated the ideology of science but led to a debate about the extent to which this autonomy is a function of society's capacity to support it.[55] The following discussion of the ideas underlying the organisation of science centres around this debate because the opposing ideas are continually used in science policy discourse. Three ideas are especially influential: the prioritisation and choice of research areas; models of the effect of research on innovation; and the concept of critical mass in the organisation and funding of research. The section also considers the way in which these ideas have been received in Australia.

3.1 Prioritisation and choice

In the early 1960s, as part of the awakening interest in science policy, there was a debate in the journal *Minerva* about the criteria by which choices are made as to which areas of science are investigated in order to create new knowledge. The debate was very influential because it gave intellectual justification to the two main streams of ideas on the process of prioritisation in scientific work. One stream was based on the notion of Polanyi, a political scientist, that science should be considered as a sovereign area of social activity into which non-scientists should not be allowed. The other, based on the ideas of Weinberg, an atomic physicist, argued that scientific activity should be regulated by criteria external to science as well as those arising from the internal dynamics of scientific creativity.

3.1.a Polanyi and scientific autonomy

Polanyi, following Merton's ideas about the ethos of science, argues that the production of scientific knowledge should be thought of as a republic in which political thought is unfettered and autonomous. The production of scientific knowledge obeys the principle of 'spontaneous co-ordination' of 'independent

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[55] Don K. Price, *The Scientific Estate*, Belknap Press, Cambridge, Massachusetts, 1965, p. 265.

initiatives' guided by an 'invisible hand' of the publication of results. This publication of results acts like a system of prices on the free market. Certain criteria must be satisfied for work to be published and therefore to be of value. The criteria are: *plausibility;* or the notion that new knowledge must be verifiable with reference to a given body of unfalsified knowledge; *scientific value* in terms of accuracy, systematic importance and the intrinsic interest of the subject matter; and *originality* of the work undertaken. Through the self-determined co-operation of scientists the 'joint discovery of a hidden system of things' proceeds more efficiently than through individual scientists working alone, or through 'any authority which would undertake to direct the work of the scientists centrally'. Such intervention would 'bring the progress of science virtually to a standstill'.[56]

3.1.b Weinberg and the need for choice

In contrast to these ideas, which of course were very acceptable to scientists arguing for control over the rules and resources for the production of scientific knowledge, those of Weinberg advocate greater accountability of scientists to society for the work they undertake. Weinberg argues that the problem of choice among scientific projects cannot be avoided or left to scientists because the proportion of societal resources allocated to science are now simply too great to allow scientists complete autonomy. Such choices have to be made by individual scientists, by research managers and by government administrators. He says:

> My purpose is to suggest criteria for making scientific choices - to formulate a scale of values which might help establish priorities among scientific fields whose only common characteristic is that they all derive support from government.[57]

Weinberg postulates that there are two sets of criteria by which such choices can be made: criteria internal to science and criteria external to science. The *internal* criteria can be expressed in two questions:

1. is the field of science ready for exploitation?
2. are the scientists in that field competent to undertake the work involved?

Such choices are made by specialist scientists on granting committees. In the case of 'small' science demanding a low allocation of institutional resources these choices can often be left to scientists. However, most projects now require justification on a wider frame of reference using *external* criteria. Weinberg lists three such criteria:

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56 Polanyi, 'The Republic of Science', pp. 2-5.
These ideas were given prominence in the 1975 Report of the Science Task Force in the form of the inclusion in the Report of a letter from Professor Harry Gelber of the University of Tasmania (Political Science) deploring the erosion of scientific autonomy.
Royal Commission on Australian Government Administration, Science Task Force, *Towards Diversity and Adaptability* AGPS, Canberra, 1975, p. 31.

57 Alvin M. Weinberg, 'Criteria for Scientific Choice', in *Criteria for Scientific Development,* ed. Edward Shils, The MIT Press, Cambridge, Massachusetts, 1968, pp. 21-33, p. 21.

- *technological merit* — once society decides that a certain technological end is desirable then the production of scientific knowledge to achieve that end should be supported;
- *scientific merit* — research should be preferred because it has the potential to contribute to a wide range of scientific disciplines; this should be decided by a panel of scientists from all such disciplines;
- *social merit* — research which has relevance to the values of a particular society.

Weinberg says that the criterion of social merit is the most difficult to apply in practice because of the problems of the definition of societal values. Decisions have to be made about whose values are pre-eminent and which of several pieces of scientific work, which may be of proven technological or scientific merit, contributes most to such values. Weinberg uses the example of 'national prestige' as a social value. Does putting a man on the moon or building a dam in a third world country contribute more to national prestige. Despite such difficulties Weinberg believes that it is essential that scientific projects should be decided according to such criteria.

3.1.c The need for change

Despite the publicity given to the debate on priorities, and the fact that the economic stringencies of the 1970s meant that the allocation of resources to science became more problematic, there was no great advance in the 1970s in the techniques of research prioritisation.[58] In 1972 the OECD reviewed the use of analytical techniques in decision-making for research and development and concluded that such analytical techniques as Delphi, performance evaluation review techniques, program performance budgeting systems, relevance (decision) trees and demand models can only supplement normal policy-making structures by aiding the rationality of choice. They cannot alter the fact that policy-making is determined by the structures in which decisions are made.[59]

By the 1980s it was clear that the golden age of funding for research and development was over. Ziman used the term 'steady -state' to describe the situation in which policy-makers were allocated a constant supply of resources with which to fund an ever-increasing set of potential research projects.[60] This situation meant that science policy-makers would need models of choice based on more than scientific judgement.

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58 Weinberg himself writes of only one method, developed by Bromley in the USA to allocate resources to sub-field of physics, which was developed from his approach. Ibid., pp. 7-9.

59 OECD, *Analytical Methods in Government Science Policy,* OECD, Paris, 1972, p. 72.

60 J. Ziman, *Science in a "steady state": The research system in transition.* Science Policy Support Group, Concept Paper no. 1, 1987.

In 1984 Martin and Irvine, of the Science Policy Research Unit at Sussex University, were arguing that the peer evaluation system advocated in pure form by Polanyi, and in moderated form for basic science by Weinberg, was inadequate to the demands of science policy in the 1980s. They take Weinberg's analysis as a starting point, saying that his external criteria have, to a large extent, remained implicit in decision-making for science policy with the result that the resulting allocations have reflected the values and commitments of powerful interest groups rather than of society. Peer evaluation depends on scientific 'gatekeepers' who regulate the flows of information and financial resources through the scientific community. As budgets level out or fall, and the demands of the scientific community increase, governments attempt to make decision-making at increasingly low levels open to more explicit external criteria, including economic criteria.[61]

According to Martin and Irvine, the consequence is a circle of influence in which the agencies of decision-making become ossified towards particular disciplines; research becomes concentrated into a smaller number of large institutions; the number of influential actors concentrates in a similar fashion and truly disinterested peer evaluation becomes impossible as all researchers in a subfield of science are in the same network of influence and resource allocation. There is a bias against funding new disciplines and a built-in resistance to closing down facilities which are no longer productive or relevant to national objectives.[62]

In these circumstances considerable changes need to be made to the agencies of decision-making for science policy in order to 'open up' the processes of peer evaluation and to substitue explicit external criteria for deciding priorities. This can be done by:

1. improving the data on inputs such as spending patterns to and within the disciplines and institutions of science;

2. overhauling the mechanisms of resource allocation so that peer evaluation is supplemented by the use of 'foreign peers' and 'iterative processes' such as the Delphi technique of group decision-making which avoids the pitfalls of expert committees;[63]

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61 John Irvine & Ben Martin, 'What direction for Basic Scientific Research?', in *Science and Technology Policy in the 1980s and Beyond,* eds. M. Gibbons, P. Gummett and B.M. Udgankar, Longman, Harlow, pp. 67-98, p. 70.

62 Ibid., pp. 74-78.

63 The Delphi technique consists of the canvassing of expert opinion by questionnaire about their expectations for a series of hypothetical future events, in this case the likely success of certain research projects. The results are synthesised and presented to the experts again with a request that they might like to change their views, giving reasons for agreeing or disagreeing with other stated opinions. The process reiterates until convergance and narrowing of estimates is achieved. The method is supposed to eliminate the intimidation of experts who have valid opinions but who are weak actors in committee situations. It is used in the Organisation for the Advancement of Pure Research in The Netherlands.
OECD, *Analytical Methods in Government Science Policy,* p. 43.

3. examining the way in which scientific research is organised in terms of the effects of leadership, managerial style, the size and organisation of research groups and instrumentational obsolescence on scientific performance;

4. integrating research more closely to future economic and social needs by establishing methods for identifying the economic and social costs and benefits of each project;

5. widening the membership base of committees to ensure that a plurality of opinions, interests and values are explicit in the external criteria of prioritisation.

3.1.d Martin and Irvine and 'research foresight' in the 1990s

By 1989 sufficient interest had been shown by policy-makers in the ideas expressed by Martin and Irvine that they had developed the technique of *research foresight* which they describe as: '...a systematic mechanism for coping with [the] complexity and independence of long-term decisions on research'.[64] Martin and Irvine say that the need for research foresight is even greater at the end of the 1980s than it was earlier in the decade. The internal and external conditions of research have changed dramatically. Internally, basic science is now of great strategic importance economically because of the fact that the four fields of research yielding the most revolutionary results in industrial terms (electronics, information, communications, advanced materials and biotechnology) are all based on molecular or atomic-level analysis. This has led to greater emphasis on university research.

Research in these areas needs costly instrumentation and facilities at a time when, externally, Ziman's steady state of resources looks likely to continue into the 1990s. The peer evaluation system of resource allocation based on disciplinary reputation is unfitted for the task of deciding which areas of science have the greatest technological potential. Most advanced nations now trade within in a global economic system of increasing diversity, complexity and consequent interdependence. This makes accurate prediction essential since mistakes in foresight are costly and have wide ramifications. Martin and Irvine say that the forecasting techniques of the 1960s and 1970s failed to anticipate events such as the oil crisis because they do not take into account socio-political changes.

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[64] Foresight was developed by Coates in the USA to factor these changes in to public and private policy-making. They use Coates' definition of foresight as:

> A process by which one comes to a fuller understanding of the forces shaping the long-term future which should be taken into account in policy formulation, planning and decision-making. Foresight includes quantitiative and qualitative means for monitoring clues and indicators of evolving trends and developments and is best and most useful when directly linked to the analysis of policy implications. Foresight prepares us to meet the needs and opportunities of the future. Foresight in government cannot define policy, but it can help conditions to be more appropriate, more flexible and more robust in their implementation, as times and circumstances change. Foresight is, therefore, closely tied to planning. It is not planning - merely a step in planning.

Ben R. Martin & John Irvine, *Research Foresight:Priority-Setting in Science,* Pinter Publishers, London, 1989, p. 1.

Foresight in science policy differs from forecasting in that it is a process which, among other characteristics:

1. involves consultation and feedback with actors in the policy community;
2. aims to understand causal relationships in possible future developments by continuous monitoring of trends and opportunities;
3. takes as a given that there will be not one but several possible outcomes most of which result from confrontation among actors;
4. recognises the complexity and interdependence of the phenomena and activities in research and therefore adopts a systemic approach to assessing the cross-impacts among the constituent processes and conflicts;
5. recognises that power expressed in social, political and motivational action is a crucial factor in information about future developments, and that openness to external scrutiny in decision-making is essential to prevent stagnation;
6. recognises that information is always incomplete and that often the most that can be achieved is greater coherence and stimulation in policy-making.[65]

The process can be applied to decision-making at all levels (macro/research field; meso/research area; micro/research project) and consists of three stages: the pre-foresight stage during which the decision is made to commit organisational resources to the foresight process and the administrative machinery is established; the foresight stage of design, analysis, negotiation and dissemination of priorities; and the post-foresight stage of either implementation or closer, micro-level foresight analysis of problem areas.

The pre-foresight stage is likely to be generated by dissatisfaction with the existing processes of resource allocation, either on the part of the organisation itself or of agencies with authority over the research activities of the organisation.[66] The foresight stage consists of four core activities: design of the foresight process; strategic analysis; agreeing on the most promising options; and disseminating the results to the science policy-makers.[67] Post-foresight activities are important in ensuring that preferred options become realities. Because priorities are decided by a process which has non-rational elements of political and bureaucratic influence, and therefore involve compromise, it is necessary to incorporate into post-foresight processes of consensus-building and what Martin and Irvine call 'anticipatory intelligence' activities to minimise the conflict of disappointed interest groups. Post-foresight includes the sub-processes of implementation, research program design and management, and the dissemination of research results.

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65 Ibid., pp. 5-6.
66 Ibid., p. 31.
67 Ibid., pp. 32-37.

Their work resembles that of Dror who developed his model of optimal policy-making in response to Lindblom's notions of muddling through. Research foresight is both as comprehensive in its scope and as complex in its processes as Dror's optimal model. Policy analysts wil recognise in the three stages of foresight Dror's phases of meta-policymaking, policymaking and post-policymaking.

All of these sub-processes depend on the way in which research activities are to be divided between or within institutions and the way in which the results are to be used.[68] Martin and Irvine work from the premise that, even if it is not possible to predict accurately the directions in which scientific research will develop (the catchcry of the more traditional elements of the scientific community), it is at least possible to make the process of the allocation of resources to research open to more than scientific opinion and optimally rational in its examination of likely developments.[69]

The most significant change illustrated by the work of Martin and Irvine is that that these analysts, who have considerable experience in working with scientists in various countries, have adopted methods of policy-making developed in public administration to change the way in which choices about research are made in the science system. This method systematically introduces non-scientific criteria into such decision-making.

3.1.c. Prioritisation and choice in Australia

The ideas discussed above gradually filtered through into the science policy community in Australia through interaction between significant actors in the the attentive public and subgovernment and their counterparts in the international attentive public. Some of these actors moved into the Australian science policy community in the 1970s. Others like Martin and Irvine came to Australia to advise governments in the 1980s. Australian academics studied abroad and brought some ideas back with them.

3.1.c.i Scientific autonomy

In 1949, soon after the restructuring of CSIRO following Menzies' 'Red scientists' allegations, the *Australian Journal of Science* published a paper by Polanyi. In the paper he stresses the need for the individual autonomy of scientists; the counter-productive effects on creativity of hierarchically-imposed co-ordination and the

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68 Ibid., pp. 37-39.

69 Similarly, Martin and Irvine's model has sixteen separate sub-processes which are remarkable similar to Dror's eighteen sub-phases of optimal decision-making. One can therefore assume that the model will form an ideal type against which less-developed models are judged, but may in the long-term prove too costly in time and organisational resources to become an established science policy mechanism. In their discussion of research foresight in Australia Martin and Irvine admit that the process is time-consuming, highlights tensions between traditional processes and foresight processes, and to be successful requires effective institutions of management and a conducive political culture.
Ibid., p. 220.
Yehezkel Dror, *Public Policymaking Reexamined,* Chandler Publishing Company, USA, 1968.

dysfunctional effects in general of centralised political control over the science system. In Polanyi's opinion the 'internal coherence of science' provides a superior form of 'spontaneous co-ordination' because scientists see their research as part of the 'spritual reality of science' which transcends centralised political control over research activity.[70] The acceptance and publishing of the paper, at a time when the *Journal* published very few papers outside the natural sciences, suggests that Australian scientists endorsed these views, or at least thought them worth debating.

Peres, a science policy writer of the 1960s, former CSIRO administrator and then political scientist at Monash University, studied at Harvard where he was influenced by the ideas of Polanyi, Merton and Storer. He supported the *laissez-faire* attitude of the Menzies/Gorton/Fraser school of conservative thinking about science policy, particularly the reluctance to establish new agencies of decision-making. In attempting to combine this ideology with that of scientific autonomy in face of the need for change he produced some contradictory proposals for the administration of science policy.[71]

Peres claimed that it was impossible to separate science policy from government policy in general, since scientific information is an integral part of some areas of government activity. This he saw as 'science as a means'. He said:

> Even if one could render "Science Policy" meaningful there remain fairly fundamental policy questions of what actions and arrangements governments should take to facilitate the use of the science means in achieving non-scientific ends.[72]

Peres then goes on to argue for separate administrative machinery for developing 'science as a means'. He does this in the framework of the centralist/decentralist debate current in public administration studies in the 1960s. His reasoning follows the following course:

- the production of scientific knowledge is now dependent on government support;
- policy for scientific activity is not separable from other government policies and therefore responsibility for it should not be isolated in a separate portfolio;
- however, if governments are to use the production of scientific knowledge as a means to achieving general national policies then this requires a different set of administrative arrangements than the production of scientific knowledge as an end in itself (ie., CSIRO);
- neither government nor scientists should have overall control of decision-making in this area;

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70 Polanyi, 'The Foundations of Academic Freedom', pp. 107-115.
71 Leon Peres, 'Organizing Science as a Means', *Public Administration,* (Sydney), vol. XXIV, no. 4, December, 1965, pp. 287-297.
72 Ibid., p. 289.

- such decision-making should be de-centralised rather than centralised, preferably with the agencies who have responsibilities for using science in their activities;
- however, this would lead to an over-emphasis on applied science and too much government control;
- therefore perhaps responsibility for such decisions should be given to industry;
- but industry in Australia has a proven record of unsophistication in innovation;
- so perhaps we should set up a system of industry research councils and hope that there is greater strength in fragmentation than in unity.

Peres raises, then avoids answering, the question of who should make the decisions about the forms and extent of funding for research, considering that it is a 'matter of judgement rather than logic' and therefore not suitable for costly 'additional pieces of administrative machinery'.[73]

3.1.c.ii Science policy and choice

Two writers in the 1960s who did tackle the thorny question of the selection of research priorities were O'Dea and Falk. O'Dea, and her co-author and boss, John Falk, Chief of the Division of Plant Industry, CSIRO, advocated the development of a new social science discipline to be called 'scienomics' - the systematic study of the impact of science and technology on society.[74] They saw the need in Australia for a body of knowledge which would inform decisions about the choice of priorities in the allocation of resources to science. O'Dea considered that scientists and government administrators had shown themselves to be incapable of facing up to or comprehending the complexity of the interaction between science and society and regarded the issue in a situation of 'bemused fog'.[75] The discipline of scienomics would need data, informed opinion and expertise in operational theory. Falk and

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73 Ibid., p. 295.
These points were made when Peres was still an administrator with CSIRO. A year later he was an academic political scientist and arguing with scientists over the advantages and disadvantages of advisory councils, concluding that: 'Whether or not an Advisory Committee were appointed, the government would almost certainly want to use a specially appointed cadre of science advisers as well'.
'The Science of Being Important', *The Australian Quarterly,* vol. XXXIX, no. 1, March 1967, pp. 28-37, p. 31.
In 1978 Peres was appointed by Fraser as a member of the first permanent ASTEC. Encel, a long-term supporter of such a Council, was not.

74 John Falk & Marjory O'Dea, 'Science, Technology and Society: An Outline of the Development of Scienomics', *The Australian Quarterly,* vol. 39, no. 4, December 1967, pp. 50-65.

75 Marjory O'Dea, 'Problems in the Administration of Science', *The Australian Quarterly,* vol. 40, no. 4, December 1968, pp. 76-88, p. 77.
O'Dea here is referring to the 1967 Royal Institute of Public Administration Conference on 'Government and the Scientist' at which Encel gave his controversial paper. It is interesting that Falk, as a CSIRO Chief, did not co-author this paper which was critical of government policy and scientific administration.

O'Dea used the *Minerva* debate as their frame of reference. They conclude that such decisions are ultimately political rather than scientific and that, given the proven lack of expertise in such matters in the political or science systems, academia would have to take the lead in disseminating and refining ideas already current overseas.[76]

3.1.c.iii Prioritisation in the 1980s and 1990s

The debate in Australia, as overseas, produced little development in the 1970s and it was not until the economic strictures of the early 1980s that further progress was made.

Johnston uses Ziman and Blume's insights to emphasise how ideas about prioritisation have changed over the past thirty years. The 1960s was the age of science as the 'motor of progress'; the 1970s was the age of science as the 'solver of problems', and the 1980s has seen science as the 'source of strategic opportunity'. However, resource allocation must now take place in a steady state situation of a finite envelope of resources.[77] These changes mean that effective processes of resource allocation are more critical than ever in selecting which scientific projects will provide the most economically productive types of knowledge.

Johnston also uses Martin and Irvine's concept of research foresight to propose that science policy should be concerned with *nurturing* winners rather than *picking* winners. He argues the need for new methods of research management. These are summarised in table 4.2 below.

Table 4.2 Johnson's investment model of management research

knowledge production	***product development***
• *a priori* goal and milestone setting; • monitoring of progress; • reviewing appropriateness of goals;	• effective linkage and rapid transfer of new knowledge within and between organisations and sectors;
securing all benefits	***opportunity scanning***
• increased intellectual secrecy; • restrictions on publication; • extensive intellectual property protection.	• knowledge of public sector research; • systematic scanning of literature; • knowledge of competitors' research

Source: Johnston, 'Strategic policy for science', p. 4.

What is important for the science policy analyst, says Johnston, is the implications of the new 'investment model of research' for the relationship between political systems and science systems. Governments need to create cultures of consensus about the nature and importance of research and to provide the *authority, credibility* and *legitimacy* that Martin and Irvine say are fundamental to the process of research

76 Falk & O'Dea, 'Science, Technology and Society', p. 60.
77 Ron Johnston, 'Strategic policy for science', *Australian Universities' Review,* vol. 33, nos. 1 & 2, 1990 p. 2.

foresight.[78] These words are at the core of ASTEC's proposed method of producing a science policy through the mechanism of a White Paper.[79]

The influence of Ziman, and Martin and Irvine can be gauged by the way in which their language has permeated the superstructural subgovernment in Australia. Both the steady state and research foresight models for science policy are explained and quoted at some length in a report commissioned by the Prime Minister from ASTEC in 1989.[80] Irvine has also spoken directly to the Prime Minister's Science Council on the development of the medical and scientific instrument industry in Australia using a combination of the higher education and manufacturing industry research granting schemes, and foresight workshops of users and producers, to plan future needs and policy.[81]

Similarly, Bell, then Deputy Secretary of the Department of Industry, Technology and Commerce, and onetime head of the OECD Science and Technology Secretariat in Paris, used both concepts in a paper on science policy given in 1989:

> In the past the expansion of funding for the research system took care of these problems. However, economic and political factors are limiting the possibilities for continued expansion. Publicly funded science is moving to a situation where there are great demands for change, but where resources will have to take place within a steady envelope of resources which is unlikely to have great scope for expansion. This steady state situation argues strongly for institutional selectivity and specialisation. Rigourous evaluation of competing research programs and justification of equipment purchases are essential. Today's problems are not purely a matter of funding levels, they require new resources and institutional change.[82]

Martin and Irvine themselves use their research foresight model to analyse Australian science policy as an example of resource allocation in a small to medium-sized economy.[83] They find that in 1989 that some research foresight processes have been used in Australia but that their impact on science policy decision-making has been limited because:

- there is a political culture which relies upon negotiated compromise and prefers rule-of-thumb judgements to objective analyses;
- research support is pluralistic with no real mechanism for establishing national priorities;
- there is no tradition of long-term planning in science policy;

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78 Ibid., p. 6.

79 ASTEC, *Setting Directions for Australian Research,* AGPS, Canberra, 1990, pp. 7-11.

80 Ibid..

81 John Irvine, 'Promoting innovation in scientific instruments: some lessons for government policy', *Science and Public Policy,* vol. 15, no. 3, June 1991, pp. 181-195.

82 Bell & Aird, *Science Policy in Practice.*

83 One of the conclusions that Martin and Irvine arrived at in their assessment of the research foresight process in Australia is that the CSIRO model of priority-setting (which was in the process of development when they were in Australia in 1989) could become a useful model for other agencies because it addresses the problem of resentment among scientists at top-down decision-making. The model was publicly presented for the first time to the 1990 NSTAG Forum by the CSIRO Chief Executive, John Stocker. The model is discussed in detail in chapter 6.

- there is a prevailing free market ideology which relies on the market to 'pick winners';
- strongly autonomous research institutions have defended the peer evaluation system.[84]

They point out that, in Australia, failure to take into account cultural, political and institutional factors has frustrated policy attempts to use scientific knowledge to achieve national economic goals. They claim that certain (unnamed) 'entrenched interests' were able to act politically to safeguard their position in the scientific community.[85] Their observations of the Australian science policy community as pluralistic, fragmented and unco-ordinated in its objectives is a strong indicator of the way in which the science system has resisted government attempts to centralise decision-making about the way in which scientific knowledge is produced and applied in Australia. This resistance will be examined further in the next chapter.

3.2 Models of science and innovation

Ideas about the way in which research and development affect economic production through the process of innovation are important in science policy-making because they indicate the points at which the process may need support from governments and private producers for the production of new products and processes. At its simplest the process is seen as one of linear cause and effect: results from curiosity-based research in a laboratory are developed into products and processes which are then produced and sold on the market. More sophisticated models of the process developed since the 1960s stress the interactive complexity of the process and the resultant complexity of organisation needed to manage it.

3.2.a Linear-sequential models

The linear-sequential model of the contribution of research and development to innovation and economic growth has been discussed above in relation to the development of economic ideas on the relationship between research and innovation. There are basically two versions of the concept: that of 'science-push' from the laboratory to the firm, and that of 'demand-pull' out of the laboratory by the marketplace. Layton says that the linear model, the result of attempts to simplify the process of innovation for mathematical analysis, has defined the 'structure and functioning of the technological social system' because of the power of its simplicity.[86] The simplicity was always an artificial analytical construct but it was a

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84 Ibid., p. 199.
Among others Martin and Irvine cite the 1981 ASTEC exercise to establish national research priorities using UNESCO methodology; the 1983 National Technology Strategy of the Department of Science; the 1986 Department of Science Research Capability Assessment Task Force; DITAC's 1986 and 1987 exercise in Selecting Technologies for the Future; and the methods used by CSIRO's Planning and Evaluation Advisory Unit (PEAU).

85 Ibid., pp. 225-227.

86 Layton, 'Conditions of Technological Development', p. 205.

powerful medium for scientists to argue for increased funding for basic research and as such it has persisted despite the fact that empirical studies refuting the linear-sequential model have been published ever since the 1960s.[87]

One of these, undertaken by Jevons, describes how the model, developed by economists has been used by scientists to justify more investment in basic science:

> The implied model of that relationship is that technology is science applied: science discovers something, technology applies it. Moreover a temporal as well as a cognitive relationship is implied. The scientific discovery determines not only what innovation takes place but also when it takes place. The timing of the innovation is determined by the timing of the discovery. D is the trigger which sets off the events which leads to industrial innovation and economic surplus.[88]

Jevons illustrates how the model can be used to defend the funding of basic science by the example of how the study Technology in Retrospect and Critical Events in Science (TRACES), funded by the National Science Foundation in the USA (the main funding agency for basic science), examined the relationship between five innovations and basic research. The study found that seventy per cent of the information could be traced back to basic scientific events. The study was later discredited as being over-simplistic in its choice of projects for examination.[89]

Science policy theorists are constantly trying to provide more realistic models upon which to base support mechanisms for the production of scientific knowledge. Pavitt says that the development of new models has occurred along four dimensions:

1. the intensity of the relationship between the direct transfer of knowledge from basic science to application varies with the field of science and the sector of economic activity;

2. the impact of basic science on technology requires inputs of knowledge from other sources;

3. basic science has an impact on technology not only through direct knowledge transfer but also through access to skills, methods and instruments;

4. knowledge transfers are 'person-embodied', involving personal contacts, movements and participation in national and international networks.[90]

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87 The most influential of these is Bruce Williams whose ideas on the contribution of research and development to economic production have been discussed above. Ron Johnston (with Gibbons) undertook a study in Britain in 1970 on the information inputs into successful technological developments.
Discussed in Fred Jevons, *Knowledge and Power,* Southwood Press, Sydney, 1976, pp. 15-18.

88 Ibid., p. 12.

89 Jevons gave this illustration in a lecture given in Canberra in 1975. Among the audience was Professor Arthur Birch who had achieved some of the basic research results which led to the development of the contraceptive pill, one of the innovations in the TRACES study. He confirmed that TRACES had 'got it all wrong' in tracing the relationship between the research and the commercial development for the pill.
Ibid., p. 21.

90 Keith Pavitt, 'What do we know about science? The case for diversity', in *The Management of Science,* ed.. Douglas Hague, Macmillan, UK, 1991, pp. 21-46, pp. 30-31.

3.2.b The Ziman model

Ziman's 'neural net' model incorporates these propositions in a 'spatial network, a multidimensional lattice' consisting of three cognitive dimensions: commodities, techniques and ideas. Basic science, applied research, technology and marketing are activities located in institutional spaces on these three dimensions. The whole network is a complex set of linkages existing between the natural world being investigated and the world market on which new goods and services are eventually traded. The linkages consist of interactions motivated by 'powerful economic, social, political and fiscal forces'. Any development in either ideas, commodities or techniques emerges from a particular indirect pathway of linkages moving between all three dimensions in any one institution or set of institutions organised around the production of commodities, ideas and techniques.[91]

According to Ziman the utility of the model lies in the way in which the flexibility of the institutions in the neural net to respond to stimuli along all three dimensions. He uses the example of the Interdisciplinary Research Centres in the UK (similar to the Co-operative Research Centres in Australia) which he sees as institutions established to facilitate interaction between the dimensions. Any attempt by governments to pre-program the activities of such centres would be counter-productive to the flexibility they are intended to enhance.[92]

Two aspects of Ziman's model demonstrate the contiguous nature of ideas about innovation since the 1960s. Firstly, the rationale of the utility of scientific knowledge in maintaining economic competitiveness remains as important as ever. Secondly, the desirability of safeguarding the"flexibility" of science institutions can be interpreted as serving the interests of scientists by recognising the autonomy of decision-makers within the scientific community.

3.2.c Models of science and innovation in Australia

3.2.c.i The linear-sequential model

The validity of the linear-sequential model was very prominent in Australia in the 1960s. It was advanced most frequently by those who stood to prosper by the science-push ideology being adopted by funding decision-makers. A typical example is White's claim, when speaking of strategies for Australian science:

> That discovery at the frontiers of knowledge should be a primary objective is justified by the history of modern industrial development. All of the most revolutionary changes in industry have had their origins in this sort of research. If we proceed only by trying to decide what we should manufacture, and then turn to science, our progress will be slow and uninteresting.[93]

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91 John Ziman, 'A neural net model of innovation', *Science and Public Policy,* vol. 18, no. 1, February 1991, pp. 65-75, p. 73.

92 Ibid., p. 74.

93 White, 'The Strategy of Australian Science', p. 194.

In 1990 the language of the linear sequential model still permeates the highest levels of policy-making. This statement is made by the Director of the Science and Technology Strategy sector of the Department of Industry, Technology and Commerce:

> ...if you're talking about the application of research results then you don't want links between scientists - they tend to develop anyway - the invisible college, even though it's not fashionable, certainly does exist. What you want to develop is interaction between different parts of the *chain,* between scientists, people involved in engineering, marketeers etc. so that people are doing research in an environment that is outward looking and not just science-led. [emphasis added][94]

The May 1989 Statement on Science and Technology includes an analysis of the 'complex' relationship between science and technology which has undertones of the linear sequential model:

> Science provides the foundation of knowledge and skill formation which makes technology possible - it provides a context of continuity with past experience and future capability. Investment in science helps to provide the core capacity which is an essential precondition to the next stage of development in technology....[95]

The concept is, not unexpectedly, often used by scientists to criticise the re-allocation of funds towards applied science. At the Profile of Science Forum, for example, a physics professor proclaimed:

> We must first convince government that technology without basic science is doomed to stagnation and, eventually, failure....Can we ask Simon Crean to convince them that basic physics is the cradle in which new technology is nurtured and that physicists are the nursemaids who make it grow into technology?[96]

The idea is enduring, partly because interests are served by its preservation and partly because basic science is indeed the source of some innovation. The problem for governments of medium-sized economies is that not all basic science is commercially applicable or culturally enriching, and that decisions have to be made about which basic science to fund. In Australia the problem has been exacerbated by the isolation of university research from commercial development and the autonomy of the higher education research funding subgovernment.

3.2.c.ii The Ziman neural net model

In Australia Ziman's ideas have not yet been formally used in the science policy literature, but his basic idea of the need to maintain linkages between different

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94 Rymer, Interview, 30.4.90.

95 Australia, *Science and Technology for Australia,* p. 7.

96 Professor A.G. Klein, 'We're in a bad way', in *Profile of Australian Science: Forum Proceedings May 1990,* ASTEC, Canberra, 1990, pp. 33-36, p. 34.

institutions of production is inherent in the views of McCracken, the Director of the CSIRO Office of Space Science and Applications:

> Thus, it is now recognised that the most effective management of science within a national framework occurs when R&D occurs that concurrently involves basic science, strategic science, applied science, development, production engineering, and operations. These several professional and technical communities, with their often irreconcilable characteristics, are thus forced to work together, and this greatly accelerates technology transfer from the laboratory to the market place. It also stimulates the reciprocal process stimulation wherein industry learns the advantages to be gained from actively commissioning research in the laboratories of the nation. The large mix of skills, and the involvement of the most competent people, necessitates that the projects will be large.[97]

The notion of networks of innovation also underlies Johnston's slogan for science policy in the 1990s: *concentration* (of research structures and projects), *co-operation* (between institutions and sectors) and *co-ordination* (of policies across government portfolios).[98] The concept is currently being institutionalised in the form of Co-operative Research Centres Program developed in 1990 by the Chief Scientist Ralph Slatyer. These Centres are joint financial ventures between research groups in universities, State and Commonwealth research organisations, private industry (in all sectors) designed to facilitate the flow of ideas, commodities and techniques.

The concept that the link between research and development is a complex network of interaction has serious implications for the autonomy of scientists. Where they formerly had managerial as well as profesional scientific autonomy they are now expected to relinquish some control in both areas. The design of new techniques of research organisation needs new attitudes from scientists socialised in the traditional modes of organisation.[99] The outcomes of this concept are examined in chapter six on the restructuring of research in Australia.

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97 Ibid., p. 148.

98 Ron Johnston, 'The Three Cs of science policy: concentration, co-operation, co-ordination', in *Science and Technology Creating Wealth for Australia,* NSTAG 1990 Forum Report, The Institution of Engineers, Canberra, 1990, pp. 41-44, pp. 42-43.

99 Ron Johnston, 'Strategic Policy for Science', in *The Research System in Transition,* eds. Susan E. Cozzens, Peter Healey, Arie Rip & John Ziman, NATO ASI Series, Kluwer Academic Publishers, The Netherlands, pp. 213-226, p. 225.

3.3 The notion of critical mass

The final concept in the organisation of research to be discussed here is that of 'critical mass'. The concept is used increasingly to justify the allocation of resources in science policy. The notion is borrowed from atomic physics where it emerged from the process of making an explosive nuclear device. Critical mass is defined as: 'The minimum mass of fissile material required in a nuclear reactor or a nuclear weapon to maintain a chain reaction'.[100] The essence of the concept is that a certain amount of energy/activity is necessary before a nuclear explosion can be triggered and maintained. In science policy the concept is used to argue for and justify the establishment of centres of scientific research consisting of a sufficient number of highly qualified scientists, adequately equipped and funded in order to produce new scientific knowledge across the entire continuum of basic to applied science.

Ziman and Healey use the concept in their discussion of the need to organise certain types of research on a national and supra-national basis. They argue that, as research becomes more costly, governments need to become increasingly selective about the projects they fund. Selectivity in this regard means the fostering of excellence, the closure of ineffective research units and the elimination of duplication of effort. One of the criteria which governments can use to decide if a research unit is worth continuing, expanding or eliminating is that of whether or not the research undertaken by the unit is up to international standards since: '...a "critical mass" of activity is needed to achieve such standards in any one field'.[101]

Ziman and Healey maintain, however, that size is an unreliable measure of critical mass since the effort and interaction needed to produce knowledge of the required standard varies between fields of science. In the field of pure mathematics, for example, the required standard of results can be achieved with individual workers. Experience in Germany in the 1970s indicated that research centres with over a hundred workers were not successful. More recently groups: '...present themselves as compact, coherent research groups that jointly tackle a programme of work, not as quasi-departments covering a whole field'.[102] Ziman and Healey introduce the notion of 'domains of specialisation' which they construe as areas smaller than disciplines such as oceanography but larger than individual research projects within disciplines. As a rough guide they suggest that, on an international scale, a domain would be an area of scientific research in which 'several hundred workers' produce a 'thousand or so' papers a year. At the national level in a country the size of Britain with 5% of the world's scientific output this would translate into about twelve scientists producing fifty papers a year.[103]

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[100] *The Penguin Dictionary of Science,* 6th edn., Penguin Books, 1986, q.v. 'critical mass'.

[101] John Ziman & Peter Healey, *International Selectivity in Science,* Science Policy Support Group, London, p. 4. (no date)

[102] Ibid., p. 9.

[103] Ibid., pp. 8-9.

Despite its widespread use the concept has not been fully explored academically by science policy analysts. Freeman says that, to the extent of his knowledge, there are no theoretical or empirical studies which justify the use of the concept in science policy.[104] Pavitt also questions the indiscriminate application of the concept across all disciplines before more studies have been done of scientific productivity in different types of organisations and fields of science.[105]

3.3.a Critical mass in research organisation in Australia

The use of the concept has become widespread in Australia. At the 1988 Forum of the National Science and Technology Advisory Group (NSTAG) an entire section of the proceedings was devoted to the 'Concentration of Resources and Critical Mass'. Green, Director of the CSIRO Institute of Natural Resources and Environment, and member of the Boards of the Centre for Technological and Social Change, Wollongong, and the National Science and Technology Centre in Canberra, explained how CSIRO Institutes are looking to the universities and industry to 'acquire the critical mass of scarce specialists' needed to 'sustain innovation in a competitive world'.[106] Green argues that the fragmentation of research effort, low level of industrial investment in research and development and lack of collaboration between the sectors of research in Australia have meant that research in the past has failed to achieve a critical mass sufficient to provide the national economy with material for innovation.

McCracken also believes that Australia's international economic competitiveness will be increasingly at a disadvantage because of the lack of large basic and strategic science projects. Such projects generate the effect that McCracken believes to be at the heart of critical mass or the concentration of research community resources. This is that large-scale, parallel research projects in Europe, the USA and Japan demonstrate that the time scale for the commercialisation of innovation resulting from the research is very much reduced. The relationship between research and economic production is enhanced because the long time focus (five to ten years) develops a skills base which is transferable within both public and private sectors; because advanced technologies are developed for the conduct of research, and because managements become competent at handling the transfer of technology between sectors. He says that such projects as the Very Fast Train or the Cape York Space Port should include criteria of critical mass used on a national scale.[107]

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[104] Christopher Freeman, Emeritus Professor, Science Policy Research Unit, University of Sussex, Interview, 1.11.91.

[105] Pavitt, 'What do we know about science?, p. 41.

[106] Roy Green, Concentration of Resources and Critical Mass', (discussion on) in National Science and Technology Advisory Group, *The Nature and Role of Innovation in the Economy,* 1988, The Institution of Engineers, Canberra, 1988, pp.151-155, p. 154.

[107] Ken McCracken, Concentration of Resources and Critical Mass, in Ibid., pp147-150, p. 150.

The concept of critical mass also lies behind the establishment of the Co-operative Research Centres. Partly through co-location of research facilities and partly through creating better linkages between institutions conducting related research, a sufficient amount of new knowledge is produced which will an impact in a certain area of interest to be developed commercially. The concept is also written into the May Statement in the form of exhortations to private sector industry to increase their level of investment in research:

> ...there are still problems with the overall amount of research funding which will require a concerted effort by both industry and government if we are to produce a critical mass of activity which will make Australia a significant contributor to, and beneficiary of, world science and technology in the 21st Century.[108]

However, the concept is not without its critics in Australia. Lowe sees the use of the concept as a political device of both governments and scientists:

> The political responses to the funding deficits of the 1980s was to concentrate the limited resources. Based partly on the widespread superstition that the achievement of a "critical mass" is a necessary precursor of high quality research and on the obvious political value of making expenditure more visible by concentrating it in large units. This approach has given us "centres of excellence", special research centres, key centres and now more special research centres.[109]

Lowe argues that concentration can have negative as well as positive effects on the productivity of researchers. Firstly, turning departments or research projects into research centres means that the best researchers have to become managers which is counter-productive to the production of scientific knowledge, particularly if they turn out to be mediocre managers. Secondly, the opportunity costs of investing in one centre the equivalent of eighteen average ARC grants has not yet been justified in terms of relative productivity. Thirdly, such centres of co-ordinated research tend to be self-perpetuating which is counter-productive to the system as a whole in terms of flexibility of response to changing priorities.

These comments alert the policy analyst that, until more studies of the critical mass concept have been undertaken, the use of the concept in science policy to justify a definite type of organisation of research may mask other interests than that of efficacy in the creation of new scientific knowledge and its application to economic objectives.

SUMMARY

The preceeding sections have discussed the predominant ideas which have informed the development of science policies in western industrial societies in the second half of

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108 Australia, *Science and Technology for Australia*, p. 5.

109 Ian Lowe, 'The dying of the light', *Australian Universities' Review,* vol. 33, nos. 1 & 2, 1990, pp. 13-18, p. 15.

the twentieth century. Two broad foci are identified: government objectives for scientific knowledge in modern societies; and the way in which the production of scientific knowledge should be organised and used. Most of the ideas originated in the period between 1945 and 1965. Since then they have been further developed as political and scientific actors in science policy communities recognise that the ideas can be used to operationalise and justify their particular ideologies. Thus, for example, political actors have used ideas from economics and political sociology to justify intervention into the way in which science is organised in the name of national interest; and actors in the science system have used concepts of extra-rational creativity to defend the autonomy they see as essential in the face of the increasingly market-oriented government objectives for research.

There is considerable evidence that ideas are transferred throught the international science policy attentive public and adopted by actors in the Australian science policy community. The final section of this chapter examines the way in which these ideas have been adopted by science policy subgovernments in Australia.

4. Ideas in the Subgovernments

Ideas derive from actors located in different sectors of the science policy community. They are articulated within the international attentive public, the attentive public, the subgovernment, or the executive core. Tracing the path of ideas through the science policy community can indicate the way in which networks of co-operation or opposition arise, achieve prominence and decline in influence.

4.1 Higher education

It would be expected that ideas about the autonomy of science would be expressed most forcefully in the higher education system where it is assumed that the most creative science is practised. The notion of 'one best man for the job' and 'his' autonomy is a conservative principle which 'fits' the traditional image of the scientist, and has influenced the way science has been funded in Australia, particularly in higher education. It is an idea about the way in which research should be organised which continued to be used by some higher education researchers in 1990. For example, at the 1990 Forum on the Profile of Australian Science at the Australian Academy of Science in Canberra, Dr Bob Ward, a former research director of BHP described the traditional way of organising research in higher education:

> A thousand years ago when I was a student we had a God Professor. He issued government money for the use of teachers; he ran the research philosophy; he ran the department; was a lecturer and so on. I objected strongly to this, but I learned a lot about research management and I now realise that it was a very effective way of doing research. One of the advantages from the government end is that they can see who's running the research. They don't have to worry about Charlie Bloggs who's a first year lecturer and they don't know anything about him. Much better to give a decent sum of money to the successful heads of departments and let them get on with the job. That has the advantage of Darwinism coming in. Successful departments attract good

> teaching staff; they attract good students; they attract good graduate students, and grow and prosper. In the fullness of time the poor departments disappear from the face of the earth. It seems to me that if we re-instituted the God-Professor we would have a basic research climate in Australia that the government could respond to.[110]

In the 1960s this view was being challenged from within the science system by the view that a wider range of socio-economic values needed to be incorporated into objectives for science. Two anonymous chemists from 'an Australian University', wrote in the *Current Affairs Bulletin* in 1962 that there should also be an advisory council of 'scientific economic' representation which would supervise national science policy; and that a comprehensive survey of existing research resources and facilities should be undertaken in Australia so that future requirements could be systematically planned. They point out that, unless there is the technological culture to develop such products and processes in Australia, basic research is no more than '...a charitable donation to the rest of the world.'[111] Implicit in this criticism is the idea of systematic techno-economistic planning for research.

The advent of ASTEC in 1978 gave academic scientists an influential forum for the discussion of ideas about science policy. Half the membership of the original Council were university scientists and until 1992 the Chairman has always been an academic scientist. ASTEC acts both as a conduit, distiller and modifier of views from scientists about that relationship between the political and science systems. Since the early 1960s the Federation of Australian University Staff Associations (FAUSA) had maintained the traditional view of the university scientist.[112] When the higher education research system was being restructured in the mid 1980s FAUSA submitted its ideas about objectives for university science and the way in which it should be organised. A comparison of these ideas with the subsequent recommendations made by ASTEC to the Prime Minister (Table 4.3) shows that the dichotomy between autonomy and centralisation was as pronounced as ever.

The FAUSA perspective is the traditional stance of the university researcher re-emphasising that research in universities is for fundamentally educational purposes and that the narrower role of industrial problem-solver and innovator is secondary and incidental. The ASTEC Report sees the role of the universities as complementary to that of other government-funded research establishments in ensuring that publicly funded research is relevant to present and future socio-economic needs. The ideas expressed by ASTEC reflect Ziman's notion of an expanding science system in a 'steady state' of available resources. These ideas were to change the rules for the

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110 Dr Bob Ward, Forum on the Profile of Australian Science, Australian Academy of Science, May 1 1990.

111 Anon. 'Science in Australia: Research Today - and Tomorow', *Current Affairs Bulletin,* vol. 30, no. 7, August 1962, pp. 99-112, p.100.

112 The criteria of allocation for sectoral agencies such as CSIRO, ARC and IR&DB are discussed in chapter 5.

Table 4.3: A comparison of science policy ideas, FAUSA and ASTEC

issue	*FAUSA*	*ASTEC*
objective	• the primary role of universities is to educate creative and skilled people; • research strategies should be designed to fulfill this broad socio-economic role; • universities should not be expected to fill the mission-oriented research role neglected by industrial interests;	• the role of the higher education sector is to help solve current economic problems through the production of a skilled workforce and of basic and applied research knowledge; • researchers in universities should be accountable to the public for the selection of topics and the conduct of research undertaken;
which type of research ?	• research should primarily be curiosity-led to complement the university teaching role and not made to fit the narrow interests of industry; • if the government wishes universities to participate in competitive funding for mission-oriented research then extra resources should be made available for the teaching and research roles;	• both research undertaken for intellectual reasons and research undertaken for economic and social research can add to the knowledge base and also be useful in educating the next generation of researchers; • high quality basic research can be undertaken by focussing on areas of greatest potential for Australia an broadening the criteria for priority selection;
the criteria	• resources should therefore be allocated only to the universities where infrastructure is already developed; • research should not be concentrated in a few centres of perceived excellence in research which have a reduced teaching load; • rather a balanced development of exposure to good research should be available for all students in universities; • the existing competitive scheme of research grants should be retained on its traditional basis of excellence by peer evaluation;	• institutes of technology and colleges of advanced education should be encouraged to participate in basic and applied research suported by end-users; • the efficient use of recurrent funds for research should be improved by recognising that not all staff are uniformly research competent; • the specialisation and concentration of research effort should be encouraged in individual research institutes; • funds for the competitive research schemes supplement recurrent funds and produce high-level, relevant research results and should therefore be increased; • criteria should include: - the quality of the researcher - the research record - the ripeness of the field for commercial exploitation - potential technological and social benefit;
the process	• all current funding schemes should be co-ordinated under a National Research Scheme responsible only to a senior Minister with no specialist portfolio responsibilities;	• an Australian Research Council should be established as a statutory body responsible to the Minister for Science.

Source:ASTEC, *Improving the Research Performance of Australia's Universities and Other Higher Education Institutions*, AGPS, Canberra, 1987.
Federation of Australian University Staff Associations, *Submission to the ASTEC Review of Higher Education Research Funding,* April 1986.

allocation of resources to research in higher education for the first time in twenty years.[113]

4.2 CSIRO

By 1965 the ideology of autonomy had, for nearly forty years, underlain research undertaken by CSIRO. The principle had been established by Rivett in CSIR and was upheld by Sir Frederick White, Chairman of CSIRO from 1961-1970. He also considered that all the 'great opportunities' come out of 'frontier science', which one assumes to be basic science. Applied science should be produced in order to 'guide the political and economic decisions' to be made. Scientists should make the decisions about the research to be undertaken since neither politicians nor business leaders were capable of predicting which research would lead to economic success.[114]

White was expressing the traditional scientist's view of the relationship between the political and science systems. Scientists need resources to provide facilities for research but in return they demand autonomy in order to maintain control over the commitment-inducing system of peer response. They also expect governments to manage the relationship between production and science as long as intervention stays within the development and commercialisation activities of production. To these ends it is in the national interest that basic science, from which applied science emerges in part, should be supported by governments. These ideas about autonomy and the pre-eminence of basic science seem disconsonant with the statutory objective of CSIRO as instrumental to the needs of industry.

By 1990 new ideas about organisation and purpose had been introduced into CSIRO through re-emphasis of its industrial role, through dilution of the ideology of science in the organisation, and by introducing key personnel with radically different ideas. In 1986 Minister Jones rewrote the Science and Industry Act 1949 to re-emphasise its industrial role in the science system.[115] In the following year the Hawke Government appointed a former NSW premier, Neville Wran, to be the first Chairman of CSIRO under the new legislation. Wran saw his role as introducing an 'entrepreneurial ethos' in the Organisation.[116] One of Wran's first changes in this respect was to introduce a system of cash incentives for scientists whose results are commercialised. Such rewards go directly against Merton's scientific norm of disinterestedness and indicate the extent to which the government was determined to impose its techno-economic political ideology on CSIRO.

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[113] Aitkin, who became the first Chairman of the Australian Research Council was also a member of ASTEC and an enthusiatic endorser of the Ziman ideology which states that under such conditions concentration of and selectivity among research areas are inevitable.
Don Aitkin, 'How research came to dominate higher education and what ought to be done about it', Australian Universities' Review, nos. 1 & 2, 1990, pp. 8-13.

[114] White, 'The Strategy of Australian Science', p. 194.

[115] This aspect of change in CSIRO is discussed more fully in chapter 6.

[116] Ben Bremner, 'Cash incentives for scientists', *Weekend Australian,* Jan 25-26, 1988, p. 5.

Wran was succeeded by Professor Adrienne Clark, the first woman ever to achieve such a significant role in CSIRO, and a scientist with positive ideas about the capacity of the science system to combine excellent research with commercialisation.[117] In 1991 John Stocker was appointed to the position of Chief Scientist in CSIRO from a background of industrial research - the first Chief with such extensive experience of commercial science. These personnel changes have introduced into CSIRO new ideas about the way research is organised and the ends to which research is produced. The changes have led to a new awareness among CSIRO staff of the complexity of the scientists' role in modern society and of the need to collaborate both with each other and with all sectors of society. These outcomes of changing ideas in science policy are discussed further in later chapters.[118]

4.3 Manufacturing industry

The business community traditionally have four main concerns about science policy and the views and ideas they express are usually centred around these concerns. They are: the role of government in industrial research and development; the nature of research to be undertaken in private laboratories; the responsibility of training scientists to work in industry, and the question of ownership of the intellectual property of scientific knowledge.

In the mid 1960s the industrial scientific community in Australia became aware of the fact that the relationship between economic production and the production of scientific knowledge in Australia was underdeveloped. The sort of government intervention that was becoming the norm in rural economic production had not extended to manufacturing industry.[119] Several industrial research managers were stimulated to speak out on the issue by the findings of the Vernon Committee of Economic Enquiry which pointed to the low level of industrial innovation in Australia; by the burgeoning interest of the Deputy Leader of the Opposition in science policy; and by the realisation that industrial research and development was a valid concern of government.

Their ideas were based on the premise that the relationship between the processes of industrial innovation and the production of scientific knowledge is a two-way relationship. Sir Ian McLennan, the Chief General Manager of BHP explained the premise in the following way. Industry has problems which need to be solved and basic science may be able to provide the solution immediately. However, the basic scientific knowledge for such a solution may not yet have been created and industrial problems can therefore generate the production of new scientific knowledge.

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[117] Adrienne Clark, 'New plants for old', *The Uncertainty Principle,* ed. Robyn Williams, ABC Enterprises, Sydney, 1989, pp. 205-217.

[118] Merilyn Sleigh, Science and Government - III', *Canberra Bulletin of Public Administration,* no.. 68, March 1992, pp. 91-94, p. 92.

[119] The term 'industrial research and development' has not normally, in Australia, included rural research.

McLennan was very scathing about the attitude of university researchers in the 1960s who embued their students with the idea of applied research as second-class science.[120]

This cultural separation was also deplored by Lusby, writing on behalf of the AIRG.[121] He noted that that there was a need for universities to accept applied research work for higher degrees which was directed more to Australian industry's needs than to the objective of attaining status in the international science arena. The concentration on basic research had a two-fold effect. Firstly, it did not produce new products and processes which could be commercialised in Australia; and secondly, the university system produced postgraduate researchers with skills attuned to basic research who were leaving Australia because there were not enough positions in the basic research areas for which they had been trained. He said that the same ideas about research predominated in some divisions of CSIRO:

> CSIRO through its Division of Radiophysics has, as a matter of policy, sought in recent times to work in special fields that are of world wide prestige but which have had little direct bearing so far on public usefulness; for example, radio astronomy and cloud seeding. While large sums have been expended on radio telescopes, most of the contract work has been placed overseas.[122]

The solution would be to concentrate more government spending locally; to align higher degree research work in universities closer to industry; and to change the anti-industrial philosophy in universities by using part-time lecturers from industry who would not only teach industry-related skills but also act as role models for young scientists. University staff should be encouraged to spend their sabbatical leave working in industry and this should be accorded as much prestige as working in overseas universities.

It is interesting that in the period 1965-1972 there was very little discussion by researchers in the private sector (or in CSIRO) about the issue of intellectual property. It is probably an indication of the lack of interaction between CSIRO, the universities and industry that the issue was not considered significant in science policy.

In 1990 the manufacturing industry science policy community interacts within a more centralised model of the relationship between governments and private industry over the issue of research and development. Extensive government intervention in the allocation of resources by CSIRO and the universities to the type of scientific research

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120 Sir Ian McLennan, 'Scientists and Industry', *Australian Journal of Science,* vol. 30, no. 1, 1966-67, pp. 20-23.

121 In 1964 the Australian Industrial Research Group was formed by managers in private industry concerned to improve the quality of research management in Australia, and: '... to stimulate and develop an understanding of research as a force in economic, industrial and social activities'.
K.T.H. Farrer, *AIRG: The First Twenty Years,* Australian Industry Research Group, Melbourne, 1986, p. 2.
M.M. Lusby, 'Science Policy towards the Electronics Industry', *Search,* vol. 1, no. 4, October 1970, pp. 142-144.

122 Ibid., p. 143.

which the government perceives as being of benefit to national economic well-being has become a familiar political rhetoric, if not always an implemented reality. Ideas on science policy have been formally articulated to governments through industry representation on ASTEC for over twelve years. The private research community is represented not only by the AIRG but on an individual researcher basis by the AATSE, by the Institution of Engineers and by FASTS. These groups co-operate to produce each year the NSTAG Forum which evaluates science policy. They are an example of the way in which structured interaction can be designed by actors with resources to influence policy formulation with their ideas. The way in which these groups interact within the policy community is the subject of the next chapter.

In 1989-90 the AIRG submission to the Joint Committee of Public Accounts Inquiry into Public Sector Research and Development: '...strongly supports the initiatives of the Department of Industry, Technology and Commerce to stimulate an increase in the level of industrial R & D in Australia.[123] The AIRG in particular praises the universities for developing 'skills to manage the interface with industry'.[124] The AIRG feel that if research is contracted out to be performed by CSIRO the arrangements for property rights, exclusive licence, royalties or licence fee and publication rights should be different to those pertaining when the research is performed jointly by private laboratories and CSIRO.

The AIRG represents large research investors in well-established industries and companies. Such high technology companies as Pacific Biotechnology, Nucleus Ltd and Crocker Research have benefited from IR&D initiatives and have positive views about government intervention. Less enthusiatic submissions were received from companies who felt that too much emphasis was placed on the research side of the innovation equation and not enough on the development and commercialisation side. So, for example, the Australian Pharmaceutical Manufacturers' Association commented that while their members were receiving government grants for research, there were limited government funds for commercialisation, and the pricing regulations on prescription drugs favoured pharmaceutical products developed overseas.[125] The most stringent criticism and innovative (and controversial) ideas came from businesses involved in the commercialisation process.[126]

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[123] Joint Committee of Public Accounts, *Inquiry into Public Sector Research and Development*, AIRG Submission, vol. 2, pp. S1024-S1026.

[124] An indication of the utility of these skills to industry is the fact that the universities' share of private research contracts has risen from 26 per cent to 57 percent. In contrast, CSIRO's share has fallen from 57 per cent to 26 per cent. The reason lies mainly in CSIRO's unrealistic expectations of the value of its intellectual property input to joint ventures.
Ibid., pp. S250-S253.

[125] Joint Committee of Public Accounts, Inquiry into Public Sector Research and Development, Australian Pharmaceutical Manufacturers' Association, Submission no. 17, vol. 1, p. S123.

[126] Out of 102 submissions surveyed for this thesis, 16 were from private firms in manufacturing industry or their representatives. 8 were strongly supportive of government intervention, 3 were moderately supportive and 5 strongly against it.

For example, Roach of the Sydney Business and Technology Centre claims that the continuing lack of successful commercialisation of research results in Australia is due to the fact that the process is largely managed by public servants and academics through such devices as co-operative research centres, technology parks, management investment companies, and government or university innovation agencies. The solution is total privatisation of the development and commercialisation phase of innovation using the following process:

1. 80-90 per cent of all public sector IR&D funding should be directed to private industry research associations on the advice of a 2 or 3 person committee experienced in the commercialistion of research and development;

2. the cost-effectiveness of these centres should be continually monitored;

3. governments should encourage the development of private centres of research including the privatisation of existing public sector research agencies whose primary role is that of producing research for industrial production;

4. potential products and processes should be assessed by experts in marketing, accounting, and product protection, as well as scientists and technologists from a range of disciplines, before the development phase.

5. the whole system should exist in multi-function polises providing a context of commercial universities for the training of scientists, engineers and business managers, and the production of basic research; private research and development centres specialising in the production of applied research; and production and marketing facilities.[127]

Similarly, I. W. Shedden, of Shedden Technology Management Limited, has experience in managing research and development, evaluating new technology and commercialising new products and processes for the world market. Shedden suggests that if governments are serious about comercialising research and development they should:

1. redefine "R&D" to include preliminary market surveys and market development work;

2. continue the 150 per cent tax concession and streamline the Taxation Office approval processes which currently delay the process of commercialisation by six months;

3. allow investment in R&D syndicates by individuals as well as corporate entities;

4. allow at least partial franked dividend relief for such investment;

5. tap into superannuation funds for R&D investment;

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[127] Ibid., Sydney Business and Technology Centre, Submission no. 63, vol. 8, pp. S1008-S1022. Roach claims that 400 of these private research centres exist in Japan and 250 in the United States. He also gives a history of being ignored by State and Commonwealth agencies such as DITAC.

6. allow capital gains tax relief for new businesses specifically established to commercialise R & D results.[128]

A continuing suggestion for the provision of funds for the development of products and procresses for commercialisation is that of a levy on manufacturing industry similar to that which has proved successful for rural research. This idea was rejuvenated in a suggestion from the Institution of Engineers that such a levy could be based on the principle of the training level recently introduced by the Commonwealth Government, i.e., imposed on firms which do not already spend a certain required amount on research and development. This would eliminate the 'free rider' problem of firms later exploiting the benefits of new products and processes for which they bore no costs.[129]

There is considerable mistrust of government management of venture capital and investment funds, and general agreement that the role of government is to provide the right investment climate and a long-term, stable, straightforward scheme of incentives for companies to undertake research and development. These sentiments are expressed in a survey of sixteen senior managers of firms undertaking research and development that had achieved significant advances in innovation in the last few years.[130] The survey finds that most leaders think that, since private research and development was conducted in a context of obligation to investors, it was to be expected that there would be a tendency to low-risk strategies. Australian companies should therefore concentrate on developing overseas innovations to local conditions and leave research and development to areas such as natural resources and primary production in which Australia had natural advantages.

The ideas held by the manufacturing science policy community thus cover a wide spectrum of opinion about the role of government in the production of new scientific knowledge for economic application. However, the notion of some form of governmental support of private research and development is now almost universal. The differences lie in the degree of control retained by governments over the direction over research. Those companies who have benefited from government subsidies directed at certain areas of research support the implicit prioritisation of government funds involved. Others with more radical ideas (such as those of Roach quoted above) would prefer a neo-classical economic model of market-directed pressure groups controlling the flow of public resources used to compensate for market failure in the research, development and commercialisation of new products and services. These ideas more closely fit those of Kealey and are almost unique in the Australian

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128 Ibid., Shedden Technology Management Limited, Submission no. 55, pp. S0982-S0986.

129 Ibid., The Institution of Engineers, Submission no. 49, vol. 7, pp. S927-S938.

130 Anon, 'Science and Technology: Attitudes of Australian business leaders', *Ascent Technoogy Magazine,* no. 3, August-October 1991, pp. 8-9.

science policy community. In no other sector are there such radical ideas about the privatisation of public research organisations.

4.4 Rural industry

The importance to national economic well being of rural production, and the political domination of the Liberal-Country Party from 1949 to 1972 meant that the role of governments in the subsidisation of rural research was unquestioned. Government support for rural industry in Australia has traditionally included subsidising the cost of rural research. State departments of agriculture and Commonwealth research organisations have undertaken, at public expense, the creation of scientific knowledge to be used in rural economic production. However, changing political ideology and changing global commodity markets forced subgovernment examination of the ideas justifying government intervention. A series of reports expresses the way in which different ideas influenced rural research policy.

4.4.a The Vernon Report

In 1965 the Committee of Economic Enquiry based its discussion of the economic impact of research and development on the premise that:

> The relationship between research and development and the growth of productivity is self-evident. Research and development contribute to technological change and innovation and to rising standards of technical control and management which are important elements in increasing productivity.[131]

The Committee found that productivity in rural industries had increased because uncertainties in global markets had been offset by increased productivity. This was due to the decreasing costs attributable to innovations in production methods brought about by the application of research results to production.[132] The system of government support for rural industry research funds should therefore be continued. If there was a weakness in the rural research system it was in the sometimes inefficient application of research results to production. This could be improved by further development of agricultural extension services.[133]

The way in which rural research was discussed in the Report underlines the taken-for-granted nature of government subsidies. The Report contained an entire chapter devoted to the role of research and development in economic production. Rural research was barely mentioned in this chapter which gave a detailed rationale for government subsidisation of research for manufacturing industry. Instead, rural research was discussed in the same chapter as rural industry and included no such justifications.

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[131] Committee of Economic Enquiry, *Report 1965*,p. 418.
[132] Ibid., p. 182.
[133] Ibid., p. 424.

4.4.b Whitlam challenges the assumptions of subgovernment

When the Whitlam Government took office in 1972 the political ideology for science changed to one in which manufacturing industry became the target of techno-economism. Whitlam commissioned an enquiry into rural policy which included an examination of the issue of government subsidies to rural research.[134] The enquiry endorsed the importance of research in rural policy on the grounds that increased input costs and market uncertainties required the continued expansion of exports, which in turn depended on rural research to maintain productivity. Unlike the Vernon Report, the authors of this Report justified their findings in terms of economic theory, in this case, market failure:

> Private costs and benefits could, in principle, still be sufficient to stimulate an adequate level of research even though social returns might be considerably higher. Because of the atomistic nature of farm enterprises and the difficulty for any individual or group of individuals to retain for themselves the benefits of the research results, the government needs to play a rolc in institutionalising the provision of research funds....[135]

The Report concluded that governments would always need to provide a 'considerable proportion' of rural research funding' because of the indivisibility of the benefits of research. The exact level of subsidy could not be calculated because: 'Research is a field in which it is generally accepted that the market mechanism provides a very poor guide to the efficient allocation of resources'.[136] However, governments should play a role in directing the nature, quality, co-ordination and application of research and its results.[137]

4.4.c The Industries Assistance Commission Report

The Fraser Government followed up the findings of the Rural Policy Enquiry by commissioning a report from the Industries Assistance Commission on financing rural research. The Commission noted that the Rural Industry Research Funds (RIRFs) method of raising funds from industry levy meant that rural producers contributed only fifteen per cent of the costs of rural research. However, the social benefits to the general public of the returns from public sector investment in rural research were high enough to justify maintaining the system in its traditional form.[138] The Commission was influenced in its decision by the findings of the Science Task Force (Philips

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[134] Australia. Working Group, *The Principles of Rural Policy in Australia: Report to the Prime Minister by a Working Group,* Parl. Paper 32, 1974, Canberra, paragraphs 5.125-5.170.

[135] Ibid., paragraph 5.135, p. 109

[136] Ibid., paragraph 5.167, pp. 114-115.

[137] Ibid., paragraph 5.132, p. 109.

[138] The Commission examined the recommendations of the Rothschild Report in the UK which recommended a 'customer/contractor' basis for funding research projects. The customer decides on the objective to be achieved and how much can be spent on the research. The principle involves the dtermination of priorities by the customer.
Industries Assistance Commission, *Financing Rural Research,* Parl. Paper 155, Canberra, 1977, pp. 1 & 46.

Committee) against the centralisation of funding, opting instead for the 'flexibility and diversity' of the RIRFs. However, the Commission went against the Task Force's finding that scientific autonomy does not lead to a lack of accountability in research, arguing that:

> ...society is unlikely to be satisfied with the assurance that autonomy does not inevitably lead to isolation and irrelevance and that only a minority of good research scientists will concern themselves with trivial problems.[139]

Similarly the Commission found that the failure of the Standing Committee on Agriculture to fufil its role of monitoring rural research meant that there was a need for 'a central research unit to monitor such problems'.[140]

These somwhat contradictory findings resulted in the Commission recommending against centralised restructuring of the RIRFs but in favour both of centralised control of the organisation of rural research, and of decision-making on the objectives for rural research. The Commission justified its ambivalence by using Polanyi-type statements about 'good' systems of research organisation' which are '...capable of reaching fair and reasonable judgements on the needs of producers and consumers'.[141]

The implication of their findings is considerable intervention, by an overarching research committee, in deciding which research projects should be funded by the RIRFs. Such a policy was unacceptable to the cost-cutting, decentralist conservative ideology of the third Fraser Government despite the economically rational models used by Edwards and Fairbairn. The opportunity for restructuring was not used because the ideas for action did not fit scientific values of autonomy, political ideologies of non-intervention in sensitive rural electorates, and the reluctance of the Standing Committee on Agriculture to relinquish its control of rural research.[142]

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[139] Ibid., p. 45.

[140] Ibid., p. 51.

[141] Ibid., pp. 45 & 47.
See also the discussion on researcher/rural producer preferences in chapter 4, especially footnote 111.

[142] Lazenby & Williams claim that it was the influence of the SCA which continued the fragmented and inefficient use of rural research funds. They write:

> The Standing Committee on Agriculture, which was established in 1927 to co-ordinate rural research in Australia, in fact very rapidly became the major mechanism to define the boundaries and maintain the separateness of the research institutions....The outcome of this situation is that neither the overall program of rural R&D nor the infrastructure required for such activities has been developed in response to national opportunities or needs. For example, a survey in 1990 showed that there are more than 500 sites in Australia in which research for the rural industries is carried out, many of them small and with largely local objectives.

Alec Lazenby & Richard Williams, 'Rural Research: Realities and Opportunities', in *The Management of Science and Technology,* ed. Jenny Stewart, Federalism Research Centre, Australian National University, Canberra, 1992, pp. 25-32, p. 26.

4.4.d Rural research and neo-classical economic rationalism

In 1981 the Fraser Government commissioned two agricultural economists to estimate the benefits to the nation of rural research.[143] The ensuing analysis entailed the first methodically rigourous examination in Australia of the macro-level economic costs and benefits of rural research. The authors were the first explicitly to raise the issue of why rural research should *not* be undertaken in Australia. They specifically addressed the question of whether it was not more efficient to buy overseas knowledge and apply it to Australian conditions. In doing so they used the argument that the creation of scientific knowledge only has social and economic benefits if it is applied to society's needs expressed in market terms. They claim:

> The economic rationale of research is that, by easing the constraints on to production and consumption imposed by a society's limited resources of labour, capital, natural resources and knowledge, it increases the range of society's options.[144]

Edwards and Fairbairn calculated that rural research was only justifiable in Australia if the benefits could be appropriated by Australian producers but not by the rest of the world. For example, if research resulted in cost reductions of ten per cent for Australian producers, and no cost reduction for the rest of the world, then Australian producers could, in some rural industries, appropriate up to 94 per cent of total world gains from the innovation. They concluded that the only research to be undertaken in Australia should be:

1) to investigate promising areas of research undertaken overseas;
2) to undertake research which could be of benefit to Australia which had not been undertaken overseas.[145]

Edwards and Fairbairn made no attempt to translate their findings into recommendations about restructuring either the research system in general, or the rural research sector in particular to improve the efficiency of the RIRFs.

4.4.e Radical rural techno-economism

With the change of government in 1983 came a change of political ideology and a series of incremental changes to the rural research system. The establishment of an inventory of rural research by the Department of Primary Industry in 1983, and the restructuring of the Australian Agricultural Council heralded the Commonwealth Government's intention to base decisions about rural research on a more economically rational footing.[146] The new ideas for rural research were based on the 'user pays'

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143 G.W. Edwards & J.W. Fairbairn, *Measuring a Country's Gains from Research: Theory and Application to Rural Research in Australia,* AGPS, Canberra 1981.
144 Ibid., p. 1.
145 Ibid., p. 78.
146 R. Williams & G. Evans, 'Commonwealth Policy for Rural Research Past and Present: A Review', in *Workshop on the Organisation and Funding of Rural Research,*Bureau of Rural Research, 12-13 May 1988, AGPS, Part II, p. 107.

principle and operationalised within the rural policy community through the corporatisation of the RIRFs, increases in Commonwealth contributions to matching levies, and decreasing appropriations to Government research organisations undertaking rural research.[147]

Some analysts consider that the restructuring and re-allocation of resources bring the ideal opportunity finally to implement the co-ordination and concentration principles of economic rationalisation. Lazenby and Williams advocate the implementation of several recurring suggestions for rural research policy. Among these are:

1) open fora in which actors from Commonwealth and State Governments, the research corporation and research agencies can contribute to policy-making;
2) the replacement of ad hoc decision-making with strategic plans incorporating the objective of all the major interest groups;
3) the concentration of research and development projects with optimal use of human and financial resources;
4) the involvement of research corporations in maintaining the infrastructure of research agencies.[148]

Rural producers are also in favour of changes to the system, including greater participation in the control of such research agencies as CSIRO by independent boards. The National Farmers' Federation has declared itself very much in favour of the changes to research corporations and CSIRO already implemented. A representative of the Federation said, in a Workshop run by the SCA:

> Responsiveness, we have found, depends on who holds the cheque book. Hard experience has shown us that research is not particularly responsive to end user needs when scientists or bureaucrats are given all the say in setting priorities. Our feedback indicates that those research councils are working extremely well.[149]

The development and use of ideas in the rural science policy community has been influenced to a remarkable extent by conservative actors in the subgovernment and executive core using their position in policy networks to stifle the dissemination of ideas which threaten their control over the existing structures of scientific and economic production, and the allocation of resources to activity within those structures. Power has been exercised to perpetuate action beneficial to those interests and prohibit or delay ideas which would redistribute control over rules, resources and ideas through membership of influential committees and boards.

This analysis has revealed that ideas and their dissemination and adoption by significant actors have been of paramount importance in rural research. Rural research

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[147] Lazenby & Williams, 'Rural Research: Realities and Opportunities', p. 28.
These ideas are discussed in more detail in chapters 5 and 6.

[148] Ibid., pp. 30-31.

[149] John Mackenzie, 'The Views of the Rural Sector', in *Workshop on the Organisation and Funding of Rural Research,* pp. 70-78, p. 72.

science policy networks were corporatist (according to Coleman and Skogstad's typology) in 1965 and have changed only in that the degree of corporatisation has increased with the formation of the rural research corporations. The Fraser Government's laissez-faire nationalist/conservative ideology did not provide sufficient dynamic for change. Nor did the market ideas of Edwards and Fairbairn prevail against this inertia. It was the fit between neo-classical economic ideas and the ALP science policy ideology of radical techno-economism which effected change.

6. CONCLUSION

This chapter has examined the ideas which underly science policy in Australia in relation to two basic orientations: control over decisions about the objectives for science; and control over the organisation of research and development. In general these ideas come from the international attentive public and are taken up by significant actors in the science policy community in Australia to justify the way in which they influence the establishment of structures and the distribution of resources for the production and application of scientific knowledge in Australia.

The analysis shows that there has been a definite shift towards orienting science policy as part of national economic production in all sectors. The ideas have, not surprisingly, been most strongly resisted in the higher education science policy community; to a lesser but significant extent within CSIRO and adapted most readily in the manufacturing and rural science policy communities.

Ideas about government intervention in the organisation of science have been resisted in all sectors except the manufacturing sector. Here, a combination of weak scientific ideology and lack of a traditional innovation culture has been gradually transformed by governments into a more corporatist ethos in which governments and private firms participate in research and development oriented to restructuring manufacturing production in Australia. Table 4.4 summarises the way in which the ideas become orientations to science policy as they are taken up by members of a science policy community.

Ideas about government objectives for the production and application of scientific knowledge can be grouped into two categories: nationalistic-cultural and techno-economistic. Nationalistic-cultural ideas are those which see research principally in terms of international status and cultural development; and techno-economistic ideas are those which advocate that public resources should be used to fund the production of scientific knowledge which will be of economic benefit. Ideas about the organisation of the science system can be categorised into those which demand autonomy for scientists in the name of creative freedom; and those which argue that the production of scientific knowledge is too costly; too central to modern society; and too unpredictable in its effects to be left under the control of scientists.

Figure 4.2: A typology of science policy orientations

ORGANISATION	OBJECTIVES: nationalist/cultural	OBJECTIVES: techno-economistic
centralised subgovernment control	SCIENCE AS SERVICE TO THE STATE	SCIENCE AS PART OF NATIONAL ECONOMIC PRODUCTION
autonomy of the science system	SCIENCE AS SCIENCE	SCIENCE AS BUSINESS ACTIVITY

The notion of the production of scientific knowledge as a service to the state implies that the state controls both the objectives for science and the way in which research is organised. Public resources are allocated to science in order to increase national prestige. The production of scientific knowledge occurs in institutions structured according to nationalistic rather than scientific ideology. Ideas of this type underly defence science, space research, and the way in which science is seen in totalitarian societies.

Those who advocate the notion of science as science argue that research is primarily a cultural activity which enhances national prestige but that scientists should have autonomy over the organisation of science. Such an orientation to science policy sees elite scientists or their organisations controlling the direction of research which is publicly funded according to criteria internal to the science system. In Australia such policies prevailed in Liberal Coalition governments prior to 1972.

Orientations to science policy which advocate that the principal objective of allocating public funds to research is to produce knowledge which will be of national economic benefit argue that such allocation should occur not according to the criteria of scientific ideology but through co-operation among a range of science policy actors including private business organisations, unions, economists, politicians and scientists. These actors are co-opted into the subgovernment in order to formulate, implement, and evalute policies. Governments need their skills and commitment to ensure the co-operation of the science policy community in general in the successful implementation of policy.

In Australia between 1965 and 1990 there has been a shift from an orientation to science policy based on the ideas of science as science, to one based on the the ideas of science as part of national economic production. The shift has not be uniform in time or science policy sector. Higher education science policy still retains elements of elitism centred on the production of *science qua science,* in autonomous research organisations, according to scientists' priorities. Science policy for CSIRO is now oriented markedly towards economic production. Networks are corporatist with significant actors from all sectors involved in decision-making for the organisation through the mechanism of a Chairman and Board.

Manufacturing and rural science policy are *per se* oriented to economic production rather than culture and so have always been techno-economist. Significant actors in these subgovernments have not yet adopted ideas oriented to market notions of science as a business activity because government contributions to industry research at least match industry contributions. Even in 1965 manufacturing science policy has to be interpreted as oriented around ideas of national economic production rather than as business activity. Although there were no grants for manufacturing research, government intervention in the form of tariffs protected the sector from the need to innovate. However, in 1990 the selection of research priorities is increasingly decided acording to market-centred criteria.

Within the superstructural subgovernment the shift has been markedly towards science as part of national economic production with a movement away from science policy allocation decisions made by small elite groups of scientists, organised on an ad hoc basis, dictated by shifting subjective interests; to one in which a wide range of actors from the subgovernments make decisions in agencies operating according to rules specifically oriented to national economic production.

The fourth type of science policy orientation - that which sees science purely in terms of business activity - had been expressed in the attentive public by actors concerned with the commercialistion of research results but had not been more widely adopted. Ideas underlying such a policy derive from neo-classical economics and advocate minimal government intervention in the production of scientific knowledge. Such policy advocates say that nations with medium level economies should concentrate on using public funds to subsidise areas of research which are subject to market failure. The criteria for selecting these areas should be decided by market specialists and scientists, and the research should be undertaken under government contract within privately managed research organisations.

The failure of significant actors in Australia to adopt such ideas before 1990 is counterfactual to the thesis of this dissertation; namely, that ideas will be adopted by significant actors only if their interests are served by so doing. The dependence of the science system in Australia on the political system has been such that the ideas of neo-classical economics have not been welcome in the science system. Significant actors in the science system have chosen to be co-opted into techno-economistic agencies rather than risk winning autonomy at the risk of unemployment.

Since 1990 significant actors in the political system have taken up these ideas. The Liberal-National Party Coalition in Australia has absorbed some elements of a market-centred orientation into their science policy proposals. This has been more noticeable as election defeats and ALP Government science policy techno-economism have marginalised the range of alternative policies. By 1993 the Coalition was offering such policy innovations as:

- cutting general business taxation to boost investment in research and development;
- allowing increased levels of plant and equipment depreciation to enable technological upgrading;
- allowing capital gains relief to high technology companies undergoing restructuring and/or reinvestment;
- contracting out public sector high technology and research and development activities to the private sector;
- devolving more research responsibility to the States through CSIRO/ university 'research clusters';
- co-ordinating industrial and research priorities through the Prime Minister's Science Council and allowing the process to be driven exclusively by the research and business community.[150]

This policy would reduce the role of government in both the selection of objectives for publicly-funded research, and the organisation of the way in which the research is managed. The policy relies on spontaneous investment in innovation from the business sector as a result of tax cuts. The dynamic to undertake research activity comes not from governments but from the need to compete in deregulated markets. The role of government would be to maintain research infrastructure and encourage university/industry participation in research and training. There would be a strong tendency for market centred science policy to revert to notions of *science qua science* as scientists in public sector research organisations lobbied government to maintain science as a nationalistic-cultural activity.[151]

This chapter has shown how ideas from the international and national attentive publics have been adopted and adapted by the Australian science policy community. The ideas have been operationalised as science policy when they have fitted the need of significant actors within the science policy community to control the rules and resources of the production and application of scientific knowledge. The outcomes of science policy are the allocation of public resources to the production of scientific

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[150] Guy Nolch, 'Coalition unveils S&T Policy', *Search,* vol. 24, no. 2 March 1993, p. 41.

[151] Between 1988 and 1993 only two science policy documents have been available on request from the Liberal Party. One is a 4 page pamphlet entitled *'Science Policy: Preparing Today for Tomorrow,'* dating from 1989 when Warwick Smith was Shadow Spokesperson on Science and Technology. The other is a copy of Peter McGauran's 1992 speech to the Committee for Economic Development of Australia. It is therefore difficult to assess the internal contradictions of the policy. Some are immediately apparent. For example, CSIRO 'core funding' would be maintained at current levels at the same time that government research programs would be contracted out to private sector research organisations.
Liberal & National Country Party, *Science Policy: Preparing Today for Tomorrow,* Liberal Party of Australia, & National Party of Australia, Barton, ACT, 1989, p.1.
Peter McGauran, 'Commercialising Research and Development: Public and Private Sector Interaction', Address to the Committee for the Economic Development of Australia, June 9 1992.

knowledge; the restructuring of the science system as ideas about the organisation of research change; the evaluation and selection of research projects; and the application to economic production of the knowledge produced. These issues are discussed in the next chapters.

CHAPTER 4

THE ORGANISATION OF THE SCIENCE POLICY COMMUNITY

Science policy has been defined in terms of actors with authority in specified situations making decisions about policy outputs.[1] This chapter uses the policy community approach to identify and locate the key actors in the science policy community, to examine the derivation of their authority, and the way in which they exercise power to organise and re-organise the structures of science policy-making. Through such control these actors can influence the membership of subgovernments and the ideas underlying the allocation of resources and the organisation of the production of scientific knowledge. The chapter uses Coleman and Skogstad's categories of policy network, outlined in table 1.3 in chapter one, to trace the patterns of change in the types of relationship occurring in thc subscctors of the policy community through time. Two dynamic principles underlie the changes. The first is fluctuations in the economic context described in chapter two. The second is the exercise of influence and power emanating from the ideological differences between the political system and the science system; and from the ideas and resource dependencies which scientific and political actors use to further their respective interests. The principles are concretised in the structures and relationships of the policy networks and policy community, and in the policy outcomes to be discussed in chapters five to eight.

1. THE SCIENCE POLICY COMMUNITY

The science policy community exists within an arena of specialised knowledge, responsibilities and functions. Actors within the policy community share a common policy focus and, to a lesser extent and with varying degrees of influence, routinely shape policy outputs and outcomes. They range from individuals acting independently to persons occupying positions in large public and private organisations. The same individuals may also act in other policy communities. For example, the majority of members of the Industrial Research and Development Board (IR&DB) are research managers or executives of private firms and would therefore also act within the industry policy community. The policy networks of science policy are the relationships and patterns of interaction between particular sets of actors which form around particular issues of concern to the policy community.

In many respects there are at least seven separate science policy communities in Australia: defence; health; CSIRO; energy; higher education; primary industry; and manufacturing industry; each with its own distinctive subgovernment, attentive public, policy networks, and ways of controlling rules, ideas resources. There is a considerable degree of multiple membership, mobility within and between the

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1 Pross, *Group Politics and Public Policy*, p, 119.

subcommunities; and variation through time in the type of policy networks through which they interact. This fragmentation makes the analysis of science policy an exercise in identifying the degree of co-ordination among these sectors through time. Therefore it is also necessary to examine what is here called the*supersectoral subgovernment* of decision-making, allocatory and advisory bodies and organisations common to all sectors except health and defence research. The development of this set of agencies is a significant structural change in all sectors of the policy community except health and defence.

The following discussion of the science policy community in 1965 and 1990 will first examine actors and organisations in the attentive publics, both international and domestic, who are often responsible for the introduction of ideas into the science policy community. Figure 4.1 is a version of Pross's 'bubble diagram' adapted to illustrate the organisational and individual actors in the science policy community in 1965.[2] The diagram is limited by the incapacity to illustrate social space in a two dimensional medium, but it does provide a guide to the discussions which follow.

2. The International Attentive Public

In any technologically advanced society the scientific community identifies as much, if not more with the international scientific community than it does with other sectors of its own society. It is recognition by the international scientific community which brings the rewards for scientific competence.[3] Through such international science publications as *Science* and *Nature;* by giving papers at international conferences; and, increasingly, by announcing the creation of new knowledge through the general international media, scientists seek the rewards of the global science system. International scientific interaction involves networks of organisational and individual action which transcend national and sectoral boundaries and which define and perpetuate the values and norms of the science system.

A network of science policy interaction has developed in parallel with the international science system. The individuals and organisations participating in this science policy network are prominent members of national science policy communities and members of international organisations with special interests in science policy such as the OECD or UNESCO. The network developed in the early decades of the twentieth century among scientists concerned about the relationship between governments and the production and use of scientific knowledge, but it was not until the early 1960s that it began to develop as an organised activity.[4] Since then the network has grown in complexity and influence.

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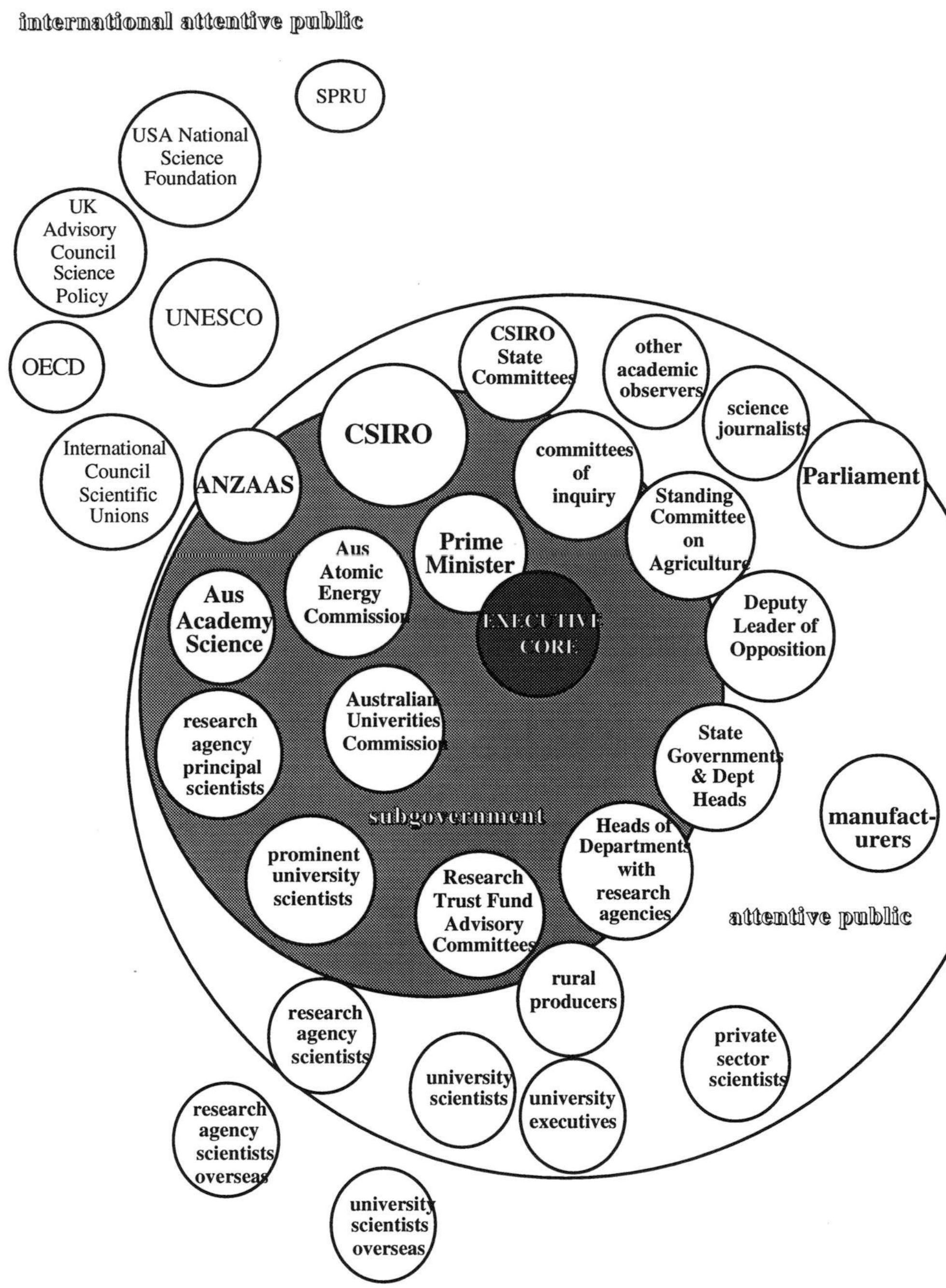
2 Ibid., p. 123.

3 See the discussion on Merton and Storer in chapter one.

4 Rose & Rose, 'The Incorporation of Science', p. 21.

Figure 4.1: the science policy community in 1965



2.1 The international attentive public in 1965

The 1960s have been described by Salomon as 'the golden age', and by Jevons as 'the dreamtime', of science policy.[5] The funding of science was relatively unproblematic because of the significant contribution of scientific knowledge to the result of the Second World War; the unquestioned ethos of economic and industrial expansion; the continuing security threat of the Cold War; and the nationalistic fervour to gain

5 Fred Jevons, *A Science Policy for the 90s: Globalisation and Localisation,* Institutute for Science and Tcchnology Policy, Murdoch University, 1989 [no page number].

ascendency in space exploration.[6] In the academic sector a growing body of knowledge was developing in centres for the study of science policy. For example, the Science Policy Research Unit (SPRU) was set up at the University of Sussex in the UK in 1966: '...in response to a growing awareness of the contributions which science and technology could make to economic progress and improving the quality of life'.[7] The journal *Minerva* was launched to provide a medium for the dissemination of papers concerned with science and society.[8] As discussed in chapter three, within this international attentive public for science policy certain ideas were becoming influential among politically active scientists and those who advised governments on the allocation of public resources to the production of scientific knowledge in the early 1960s.

2.2 The international attentive public and Australia in 1965

In 1965 the Australian scientific community was still very much a colonial offshoot of the British scientific community. Many of the top scientists in Australia had been trained by British scientists at Oxford and Cambridge who had been involved in the debate about how science could best serve society.[9] In Australia in the 1930s there had been a surge of interest in the relationship between science and society which paralleled that in Britain but no science policy specialists such as Blackett, Bernal or Zuckerman had appeared.[10] ANZAAS had loose associational connections with its British and American counterparts. The AAS had a more explicit international role, given in one of of nine objectives in the Academy's Royal Charter:

> To establish and maintain associations and relations between Australian scientists and the International Scientific Unions and other international groups, meetings and unions of scientists; and between Australian scientific activities and the activities of scientists in other countries.[11]

In 1965 the Commonwealth government funded this role of the AAS which was (and still is) Australia's 'adhering organisation' to the International Council of Scientific Unions.[12] Since the late 1950s it had also been traditional for a Fellow of

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6 Salomon, 'Science Policy Studies and the Development of Science Policy', p. 56.

7 Geoffrey Oldham, 'Director's Introduction: SPRU at 25', in *Science Policy Research Unit Annual Report 1990-91,* University of Sussex, 1990, p. 7.

8 The Editor, *Minerva,* vol. 1, no. 1, Autumn 1962, pp. 5-17, p.5.

9 Ron Johnston, 'Social Responsibility of Science: The Social Mirror of Science', in *The Commonwealth of Science: ANZAAS and the Scientific Enterprise in Australasia 1888-1988,* ed. Roy McLeod, Oxford University Press, Melbourne, 1988, pp. 308-325, p. 310.

10 In January 1939 at a meeting of ANZAAS in Canberra entitled *Science and Society,* the Chief Executive of CSIR, Sir David Rivett, advocated that scientists in Australia could best serve the interests of society by becoming involved in ' legislative and administrative areas'. Reported in 'Science and Society: Summary of the Contributions to the Discussion held by the ANZAAS during its meeting at Canberra', *The Australian Journal of Science,* vol. 1, no. 4, 1939, pp. 116-119, p. 117.

11 The Australian Academy of Science, *The First Twenty-Five Years,* The Australian Academy of Science, Canberra, 1980, p. 212.

12 The amount in 1965 was $88,000 (approx. $750,000 in 1990 values).

the Academy to chair the Committee for Natural Sciences of the Australian Commission for UNESCO. In 1972 the Natural Sciences Committee was restructured so that:

> Jointly with the Executive of CSIRO, the Academy was invited to forward a panel of names to the Minister, who appointed the Committee. The result was a greater number of Fellows on the Committee and a stronger voice for natural science in the Commission. Since 1972, when these reforms were implemented, the Academy's policies have been more influential in determining the Government's briefs to its delegations to the UNESCO General Conferences.[13]

However, the predominant form of interaction in science policy issues was through strong personal networks. Oliphant (see section 6.1 below) had been a colleague of Zuckerman's at Birmingham University before the war and had communicated with Blackett and Bernal.[14] He brought to the Australian science policy community many relationships developed in the 23 years he had spent overseas in such institutions as the Lawrence Livermore Laboratory at Berkeley, and the Cavendish Laboratory at Cambridge. Other prominent scientists had similar connections, though none perhaps as influential in the post-war global science policy arena as those of Oliphant. Oliphant was particularly influenced by the science policy achievements of Sir Henry Tizard in Britain in setting up the Advisory Council for Scientific Policy.[15] As mentioned in chpater 3, Zuckerman's influence was also introduced through the ALP which at the time was preparing the first electoral platform in Australia to address science policy issues. Morrison, Minister for Science in the first Whitlam government, describes the process of writing the ALP Science Policy:

> When we came to power in 1972 we had a very detailed set of science policy recommendations in the federal platform. Science policy was very much the flavour of the decade in the 1960s and a lot of it was derivative of Harold Wilson's efforts in England.[16]

International connections in science policy in Australia in 1965 were therefore confined to a narrow spectrum of opinion and advocacy emerging from the scientific communities of Britain and, to a lesser extent, the USA. Australia was not yet a member of the OECD and techno-economistic ideas were being introduced through scientists' influence on both Liberal Party and ALP politicians. Contact was through personal interaction with some formal representation of organised interests. There was virtual autonomy from the state - indeed the state was dependent on the personal

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Australia, *Advance to Treasurer - Statement of Expenditure,* Parl. Paper 314, 1964-66, vol. V. p. 581.

13 The Australian Academy of Science, *The First Twenty-Five Years,* p. 133.

14 Stewart Cockburn & David Ellyard, *Oliphant,* Axiom Books, Adelaide, 1981, pp. 131 & 134.

15 M.L.E. Oliphant, 'Science and the Survival of Civilization', *The Australian Journal of Science,* vol. 21, no. 1, pp. 8-16,.pp. 10-11.

16 Morrison, Interview, 1.11.89.

connections of the scientific community for international input into science policy in Australia. The policy networks of the international attentive public therefore fit Coleman and Skogstad's category of clientele pluralism in which the state identifies with, and is dependent on, the skills and information of organised interests. At this stage in Australia's science policy those interests were professional (scientists) and political (Whitlam) rather than industrial.

2.3 The international attentive public in Australia in 1990

In 1990 the number of organisations through which the state interacts with the international scientific community is larger, covers a wider range of associational types and is included as part of Australian international commercial activity. The interaction is still fragmented, but the techno-economistic objectives of the state have imposed a more formal structure on relationships which are directed to socio-economic rather than professional scientific ends. In 1990 the AAS is still representing Australia in international science, as is AATSE which represents Australia on the International Council of Academies of Engineering and Technological Societies.[17]

The Commonwealth government now represents Australian researchers directly by promoting Australian science on a commercial as well as on a cultural and educational basis. DITAC's International Program is designed to make Australian science, technology, industry and services more visible to potential overseas customers and investors. The Australian Industry, Science and Technology Counsellor Network, based in London, Washington, Tokyo, Bonn, Brussels and Paris is part of DITAC's outreach activity designed to promote and maintain a two-way flow of information between the host country and Australia on science and technology policies and investments.[18] DITAC is also responsible for overseeing negotiations concerning the science and technology-based international multi-function polis which is to be established near Adelaide.[19]

The Department of Foreign Affairs and Trade manages Australia's relations with UNESCO and the OECD, and administers bilateral research agreeements. In 1991 the former Minister for Science, Barry Jones was elected to the Executive Board of UNESCO as part of the attempt to reform UNESCO programs. The Australian International Development Assistance Bureau (AIDAB) now not only organises development assistance but has an entrepreneurial role in linking Australian innovation with commercial interests in developing countries.[20]

DEET has an International Division which works closely with the Higher Education Division to promote international awareness of Australia's scientific

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17 Ross, Interview, 3.5.1990.

18 *Scitech Technology Directory*, pp. 30-31.

19 Department of Industry, Technology and Commerce, *Annual Report 1990-91,* AGPS, Canberra, 1991, pp. 79-93.

20 Department of Foreign Affairs and Trade, *Annual Report 1990-91,* AGPS, Canberra, 1991, pp. 146-150.

knowledge and research capabilities and thereby contribute to international competitiveness and economic development.[21] CSIRO's International Relations program is similarly designed to advise the Chief Executive and Directors of such matters and to provide information for a corporate policy which will facilitate CSIRO's contribution to world science.[22]

One area in which interaction is science-led rather than government-pushed is the access for Australian scientists to multi-national consortia science facilities. In the absence of government commitment to participation in such activities as the European Organisation for Nuclear Research (CERN) or the Tsukuba synchrotron light source, research organisations such as ANSTO, CSIRO, the ARC, the Australian National University and the University of New South Wales have formed a consortium which provides resources to ensure such access.[23]

The way in which Australia participates in the international science policy community has undergone a shift from an orientation to cultural and educational issues to one focused principally on economic activity. Such techno-economistic interaction is undertaken by scientists overseen by the political system rather than by the science system. The dynamic underlying the interaction is of economic well being rather than scientific recognition.

The policy networks which have developed do not exactly fit any of Coleman and Skogstad's categories. They are not state-led because scientists still play an integral role in policy formulation. They are not concertative because state and non-state activity is fragmented and pluralistic. They are not clientele pluralistic or pressure pluralistic because the state has assumed leadership in the direction of policy. The closest fit is with the corporatist category in which consumer/producer groups combine with government to negotiate better conditions: in this case for the globalised commercialisation of Australian research. The prominent leadership role taken by the state is balanced by the state's dependence on interest groups for commitment to policy implementation. However, the corporatist networks are to a large extent sector-specific without overarching co-ordination.

3. The Attentive Public

The attentive public is the most volatile part of the policy community with actors moving in and out, to and from both the general public and the subgovernment in line with changes in their interests; their capacity to organise to promote and protect those interests; the fit between their norms and values and the norms and values of the dominant actors in the subgovernment; and the salience of those interests to the policy objectives of dominant actors in government and non-government organisations. The

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21 Department of Education, Employment and Training, *Annual Report 1990-91,* AGPS, Canberra, 1991, pp. 52-57.

22 CSIRO, *Australia's Science: Australia's Future,* p. 139.

23 ASTEC, *Major National Research Priorities: A National Program,* AGPS, 1992, p. 6.

attentive public is also the least cohesive part of the policy community. Members' interests do not lie in maintaining consensus and keeping a relatively narrow policy focus, but in broadening issues and action arenas to encompass policy areas in which they have specific expertise or resources which cannot be ignored by the subgovernment.[24] The following section identifies the attentive public of Australian science policy in 1965 and 1990.

3.1 The attentive public in 1965

The attentive public consisted of individuals in public and private agencies with an interest in the relationship between governments and the scientific community.[25] Some elements of the attentive public were more closely integrated to the international attentive public or the general public than they were to the science policy subgovernment. With the exception of ANZAAS there were no organised interest groups specifially oriented to the scrutiny of science policy and even ANZAAS' interest waxed and waned. In 1962 the ANZAAS Sydney Jubilee Congress had included a discussion on science policy centred around an article in the*Current Affairs Bulletin* which advocated a national science foundation and an advisory council on science policy.[26] However, until 1970, when ANZAAS was re-organised and the *Australian Journal of Science* became the more outward-looking*Search,* ANZAAS' contributions to science policy were limited to its Congress activities.[27]

A key concept of the policy community approach as outlined in chapter one is that traditional political institutions are not the primary unit of analysis. Therefore Parliament, which in some models of policy analysis would be a key agency stressing responsible government, is, in the policy community approach, of interest only to the extent that its decisions and advice significantly influence the policy process. In 1965 Parliament was not a forum for science policy formulation. There were no Standing Committees on Science and Technology to oversee the reports of public research organisations or scrutinise their activities. This was left to Ministers and individual members. One CSIRO Division Chief reported: 'It is the despair of an increasing number of scientists that there is little intelligent or informed discussion on science from either side in Parliament'.[28] The most significant debates on science policy issues in 1965 centred on Menzies' presentation of the Martin Report, on appropriations to CSIRO as part of the Budget debate and on the Second Reading of the Meat Research Bill.[29] On each occasion the Deputy Leader of the Opposition,

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24 Pross, '*Group Politics and Public Policy*, p. 122.
25 Davenport, 'The Impulse of Science in Public Affairs, 1945-1986', p. 86.
26 'Science in Australia', *Current Affairs Bulletin,* vol. 30, no. 7, August 13, 1962, pp. 99-112.
27 Davenport, 'The Impulse of Science in Public Affairs, pp. 88-89.
28 Walter Boas (Chief, Division of Tribophysics, CSIRO), 'On being scientific', *The Australian Quarterly,* vol. XXXVIII, no. 2, June 1966, pp. 41-53, p. 52.
29 Australia, House of Representatives 1965, *Debates,* vol. H of R 46, pp. 267-274; and *Debates,* vol. H of R 48, pp. 1859-2087; *Debates,* vol. H of R 48, pp. 2597-2731.

Gough Whitlam, used the opportunity to engage in rhetoric about the Government's lack of planned science policy.[30]

State governments straddled the boundary between the attentive public and subgovernment. They financed research laboratories in State departments, made an indirect contribution to research through university funding, and a direct contribution for the first two years of the Australian Research Grants Scheme. They received monies from the Commonwealth government in the form of special purpose payments for such programs as agricultural extension services and the National Sirex Fund, but it was the scientists at Commonwealth and State levels and not the State governments who controlled the direction and use of the research.[31]

The Australian Vice-Chancellors Committee (AVCC) played a subdued role in science policy formulation in the mid 1960s. The AVCC members were the most powerful actors in the university system, and, as almost two-thirds of all university departments in the 1960s were science-based, they wielded considerable influence over rules, resources and ideas within the system. However, the AVCC was perceived as a remote subgroup unwilling to tackle larger issues of higher education policy reform and does not appear to have played a significant role as a body of organised interests in science policy.[32]

University scientists were represented in 1965 by the Federation of University Staff Associations (FAUSA) formed in 1960 after the Commonwealth government assumed the major responsibility for funding universities. FAUSA was active in presenting to the Minister the perspective of the university researcher on science policy issues. For example, in 1968 FAUSA submitted a Report on Research in Universities.[33] In 1974 the Association was asked by the Whitlam government to respond to the OECD Examiners' Report at a meeting with the examiners in Canberra. In 1975 FAUSA established a Science Policy Committee.

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30 Whitlam was entirely expedient with regard to science policy. He used every possible occasion in opposition to regale the Government with the unimplemented recommendations of committees of inquiry, in order to highlight the fact that the ALP had such a policy. When he became Prime Minister in 1972 he appointed as Minister for Science and External Affairs, Morrison who had no interest or experience in the science policy area and who, as an ex-Department of Foreign Affairs bureaucrat, had far more interest in negotiating and administering the independence of Papua New Guinea.
Similarly, his second science minister, Clyde Cameron, was bitterly disappointed at being forced to resign the Labour and Immigration portfolio. At Yarralumla he told Sir John Kerr that he could throw the science portfolio appointment document into the wastepaper basket.
Science policy is not mentioned in Whitlam's account of his governments.
Morrison, Interview, 8th November 1989.
Clyde Cameron, *The Confessions of Clyde Cameron 1913-1990,* ABC Books, 1990, pp. 219-223.
The Whitlam Years 1972-1975, Viking, Sydney, 1986.

31 A more complete account of intergovernmental funding for science is given in chapter 5.

32 A.E.Alexander, 'University Organization and Government: A Century Out-of-Date?', *Australian Journal of Science,* vol. 27, no. 12, 1965, pp. 337-342, p. 341.

33 Anon, 'Report on Research in Universities', *Vestes,* vol. XIII, 1970, pp. 295-297.

At the periphery of the attentive public in science in 1965 were the non-proximal, 'coal-face' scientists who sometimes treated politics with disdain. The concerns that moved them to concerted action were threats to the universal image of science rather than local concerns. In the mid 1960s the Vietnam war, pollution, and the consequent disenchantment with science among the general public in Europe and America, galvanised the normally passive scientific community into action.[34] The emergence of the Society for Social Responsibility in Science was not provoked by local issues and failed to attract the commitment of many scientists once its immediate cause - the war in Vietnam - was over. Johnston comments:

> The history of this particular phase of the social responsibility of science reveals a pattern commonly experienced in Australia, in both cultural and political movements. Their origin is elsewhere, in Europe or the United States. The ideas are transported, frequently by visiting academics, but if they find a fertile environment in Australia, their flourishing will produce rapid mutation to correspond with the special needs, interests and opportunities of the local climate, but its foreign origin can also mean that it never effectively takes root, and quickly withers and dies.[35]

3.2 The attentive public in 1990

In 1990 the attentive public has developed into an organised network of agencies representative of the producers and users of scientific knowledge. There are some agencies which have persisted since 1965 but the majority have been established in response to the techno-economic ideology which developed in the 1970s and which was intensified and legitimated by the Hawke government in 1983.

The AAS, which enjoyed significant informal input into science policy in 1965, has lost its pre-eminence in the subgovernment and now must be considered simply as a representative pressure group in the core section of the attentive public. Other groups have emerged from the AAS because new techniques and ideas have challenged the capacity of the AAS to encompass them in an organisation which maintains its scientific integrity. For example, it was only in 1989 that the AAS considered it necessary to establish a committee specifically to deal with science policy issues. This Committee functions on the basis of weak associational interaction. It does not usually meet. Its members follow science policy issues and communicate their concerns and proposals for action by fax.[36]

The informal, elite policy network which the AAS dominated is now secondary to other networks. Figure 4.2 illustrates the emergence of key organisations.

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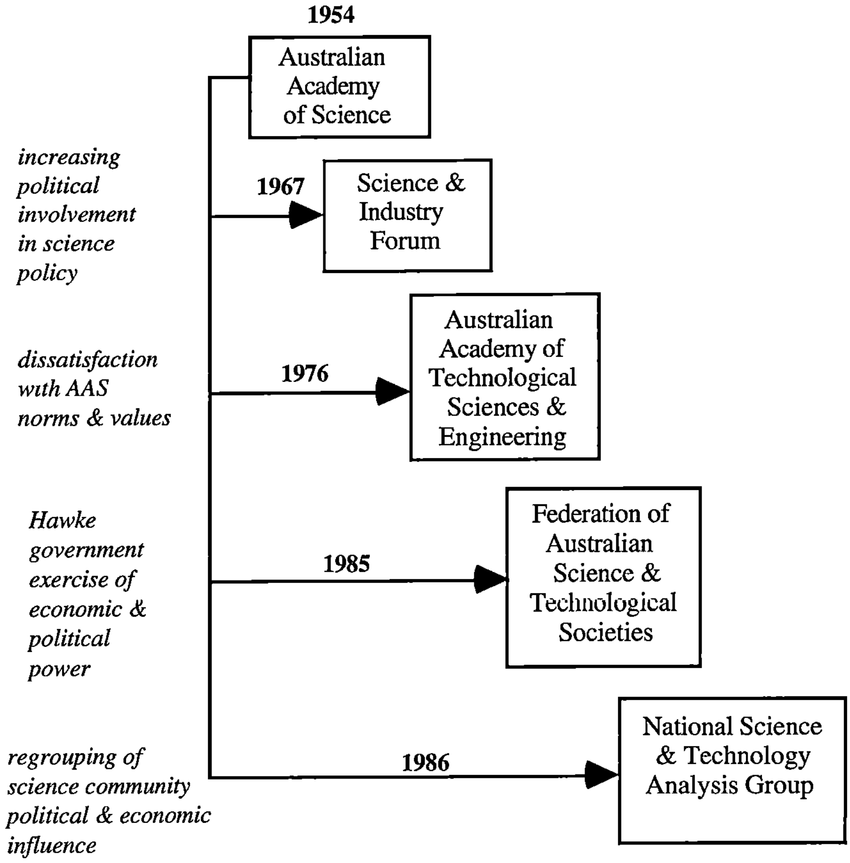
[34] They inserted full-page advertisements in the *Sydney Morning Herald* and the *Australian Journal of Science* which denounced Australia's participation in a war which used science-based weapons of destruction and offered their help in reversing the negative social and environmental effects of the application of scientific knowledge.

[35] Johnston, 'Social Responsibility of Science', pp. 315-318.

[36] Ross, Interview, 3 5 1989.

Figure 4.2: The emergence of pressure groups from the AAS



The scientific community pressure groups which have emerged from the AAS regularly and significantly influence government policy and occasionally participate in the policy process. Their members exercise influence but the agencies themselves must be considered only as the core group of the attentive public and not members of the subgovernment.

The first of the groups, the Science and Industry Forum, was set up in 1967 as part of an attempt by the AAS to stimulate the Gorton government to develop a more rigorous science policy.[37] In 1969 the Forum invited Fraser, as Minister for Education and Science, to make the first major Coalition speech on science policy in which he said:

> We may then be wisest to continue our pragmatic evolutionary approach seeking advice from different people as different projects arise. In this way we can establish a network of informal ad hoc relationships.[38]

In the previous year Prime Minister Gorton, for several years Minister-in-Charge CSIRO, had made his famous remark about an advisory council being a

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[37] The initiative again came from Oliphant who wrote to the then President of the AAS, Sir Mcfarlane Burnet, urging him to promote the establishment of an 'Advisory Council on Scientific Policy' based on the British model.
The Australian Academy of Science, *The First Twenty-Five Years,* p. 107.

[38] Fraser, 'Government Approaches to Science', p. 414.

'...group of individuals pushing the barrow for their own disciplines.'[39] Clearly policy advisory councils were not part of conservative political ideology and this fitted well the elite values of the current leadership of the AAS.

In 1976 the Australian Academy of Technological Sciences and Engineering (AATSE) was established in response to AAS intransigence on the issue of broadening the Fellowship of the Academy to include scientists of excellence in the applied sciences, particularly those employed in private sector research organisations. The new Academy, which had been critical of the relationship between CSIRO and the needs of industry, was immediately co-opted by the Fraser government into a major enquiry into the organisation of CSIRO. Professor Howard Worner, who has worked in all sectors of science over a forty-year career, and who is a Fellow of both Academies says:

> It really took the comments and the input from the AATSE that started moving people in high places, particularly in CSIRO, [towards] the report into the performance of CSIRO ...which for the first time stressed that taxpayers' money should be spent on some goal that was of benefit to the community....It caused considerable ill feeling when the report first went out, but it became the basis on which pressures built up in government to force changes in CSIRO and led ultimately to the replacement in the Chair of CSIRO of a scientist by a politician, or an ex-politician, Neville Wran. His role has been to keep pressing throughout the whole structure of CSIRO for them to change their endeavours to be more in common with the objectives of the AATSE, ie the application of scientific and engineering knowledge to practical commercial purposes. That's putting it in a nutshell. If you study the changes that have taken place in CSIRO it really began with those studies. The first that really had the courage to say it was that of the AATSE.[40]

Thus Fraser who in 1969 had eschewed the idea of intervening in the relationship between science and industry, was forced by the realpolitik of techno-economism, espoused by influential members of the attentive public, to change the rules of the organisation of the production of science in public sector science agencies. By 1984 this ideology of techno-economism, refined through the agency of the Minister for Science, was threatening the interests, norms and values of scientists by asserting state autonomy in the allocation of resources to science. Jones stung the scientists into action by labelling them as 'wimps' because of their inability to represent their interests to government other than by complaining after the event of budgetary constraints. The AAS responded to this challenge by arranging a series of meetings of scientists' representative organisations. The Federation of Australian Scientific and Technological Societies (FASTS) was born out of this confrontation.

FASTS quickly asserted itself as the flagship of the scientific community's newly-found political purpose. In addition to working behind the scenes to influence science policy decisions, FASTS used the print media to arouse public misgivings

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39 Quoted in Encel, 'Pushing the barrow uphill', p. 21.
40 Worner, Interview, 3.11.89.

about the Hawke Government's policies for science. ASTEC, through the initiative of its then Chair, Professor Ralph Slatyer, also co-opted FASTS into an annual 'independent' scrutiny of the science and technology budget.[41] FASTS claims to represent the interests of 60,000 scientists in Australia, but, like most peak associations, became a mouthpiece for the most vociferous and politically active in the scientific community.[42] Its Executive Director has consistently expressed pro-Liberal-National Party opinions in his discussions of Hawke government science policy. This led to the exclusion of FASTS from the policy process in 1993.[43]

The National Science and Technology Analysis Group (NSTAG) was established in 1986 as the Science and Technology Societies' Budget Analysis Group. It was an co-operative initiative of the AAS, the AATSE, FASTS and the Institution of Engineers. Together they represent 100,000 scientists, technologists and engineers. The Group analysed and evaluated Budget allocations to research and development and presented their findings at a public forum in November 1986. The aim of the four parent organisations was to ensure a 'proper' input into the science and technology budget.[44]

NSTAG is probably the most influential of the scientific community pressure groups. The November post-Budget public forum has become institutionalised and scrutiny of the Budget now forms only a small part of the proceedings. Each of the four parent organisations takes the responsibility of organising the Forum around a topic. The issues are discussed in sessions spread over two days and at the concluding session a set of recommendations is formulated. In 1990, speakers from public and private sector science organisations discussed ideas for the creation of wealth by science and technology in Australia. In 1989 the Forum had focussed on the nature and role of innovation in the economy. The proceedings and papers of the Forums are published each year and include a definite set of numbered recommendations for government. A measure of the Group's influence is the number of these recommendations adopted by government. Out of the 26 recommendations

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41 T.F. Smith, 'More Facts on FASTS', *Search,* vol. 17, Nos 1-2, Jan-Feb, 1986, p. 13.

42 Dr Les Rymer, DITAC, challenges the claim of FASTS to represent all scientists in Australia. He says that there is no two-way communication between scientists and the Executive of FASTS:

> To my mind FASTS does'nt really represent its members. For example, I am a member of scientific societies affiliated to FASTS but the only way I know what FASTS is doing is through reading their press releases. FASTS is developing committee mechanisms to develop views on issues but I doubt whether they are representative because FASTS interests are centred on the higher education sector and do not represent the views of scientists in industry.

Rymer, Interview, 30.4.90.

43 See, for example: David Widdup, 'Politics is People', *Search,* vol. 21, no. 1, January/February 1990, pp. 11-12, published shortly before the 1990 election; 'Five Years down the FASTS Track', *Search,* vol. 21, no. 7. October/November 1990, pp. 227-229, p. 228; 'Science and Technology Meets the Juggernaut'*Search,* vol. 22, no. 7, October/November 1991, pp. 219-220; 'Reading the Schizophrenic Mind of Government', *Search,* vol. 20, no. 6, November/December 1989, pp. 178-179.

44 Ditta Bartels, 'FASTS moves Quickly', *Search,* vol. 17, Nos 3-4, Mar-April 1986, p. 65.

made in 1988, six have been implemented by the government in either the 1989, 1990 or 1991 Budgets.[45]

In 1988 young scientists in Canberra from CSIRO and ANU set up a pressure group called Australian Science Action (ASA). They were concerned about reduced funding to CSIRO; the consequent reduction in the number of research programs which could be undertaken by the Organisation; and the likely reduction in staff numbers. The restructuring of the system of allocating research resources in the higher education sector, to areas designated to be of high national priority, were also considered to be 'contentious issues heavily tainted by political expediency'.

The ASA employed pressure group methods of political persuasion to influence not only the Commonwealth government but also the leaders of science organisations and agencies.[46] ASA interacted with Parliament and the core executive through lobbying, the presentation of submissions and personal contact. The group organised a rally at the opening, by the Prime Minister, of the National Science and Technology Centre in Canberra, which gained widespread media coverage. They invited speakers from all political parties to present 'a balanced view' of science in society. In order to gain the credibility of other scientists they attempted, and accomplished publication of the results of their survey in *Nature,* the most prestigious journal in the international scientific community. As a consequence, ASA was asked by the government to comment on the findings of the Smith Report; on the structuring of the Research Training Section of DEET; and on the ARC funding of Research Fellows. They also achieved intervention by senior Ministers into CSIRO human resources policy on staffing structures.

In addition to scientists pressure groups there are 2500 industry and trade asssociations which regularly lobby government on behalf of their member organisations. Examples are the Australian Biotechnology Association, the Australian

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45 They are:
- an annual science and technology Budget statement;
- inter-departmental co-ordination of science and technology policy initiatives;
- increased co-operative research between industry, academia and public sector organisations;
- increased stipends for post-graduate students;
- increased exemption from graduate tax for postgraduate students;
- a national fellowship scheme similar to the NH&RMC scheme;
- increased communication to industry of government R&D grants.

NSTAG, *The Nature and Role of Innovation in the Economy,* 1988.
NSTAG, *Science and Technology Creating Wealth for Australia,* Report of the 1990 Forum, The Institution of Engineers, Canberra, 1990, pp. 13-19.

46 The basic elements of the process are:
- writing letters to newspapers to gauge the extent of public reaction;
- circulating surveys among scientists with similar interests;
- assembling an empirically-based argument of the social value of scientists' interests';
- targetting sympathetic newspapers with press releases;
- securing interviews on current affairs television programs.

Morell, M., K. Hubick, & B. Wellington, 'Lobbying and Influencing Budget Processes', Paper presented to the Public Affairs Conference Science and Society, ANU, 7-9 June, 1989.

46 This does not mean that the internationality of science is a phenomenon of recent history; in fact the practice probably dates back to the foundation of universities in Europe in the 11th and 12th centuries.

Chemical Industry Council and the Australian Information Industry Association. This organised politicisation of the science system is the most significant change in the attentive public in the 1980s.[47] Pressure groups use the media extensively to engage colleagues and the general public in debate about the issues which they see threatening the norms and values of the scientific community.

The attentive public of science policy in Australia in 1990 confirms Pross' observation that pressure groups are the agents of change and criticism in a policy community. As individual and organisational actors criticise government action or inaction they form pressure groups which may or may not be taken up by the government to advise on policy matters. It is interesting in this respect that in both 1965 and 1990 a group of scientists within the attentive public chose to align themselves with the opposition parties rather than the government. The difference is that in 1965 the scientists who helped Whitlam to write the ALP's science policy chose to remain anonymous, whereas in 1990 the FASTS executive were public in their espousal of Liberal science policy.

4. THE SUBGOVERNMENT OF SCIENCE POLICY

Science is a policy arena which fits well Ripley and Franklin's observation that subgovernments proliferate in complex, hidden areas of government.[48] Until 1965 ideas and decisions about resources for the production and application of scientific knowledge were confined to the sectoral subgovernments of the science policy community. Interaction occurred through networks of clientele pluralism in which separate groups within the science system assumed a policy advocacy role for their particular set of policy issues and interacted individually with the state which depended on their expertise, information and compliance. A superstructural subgovernment, of actors with portfolio responsibility and actors who advised on science policy, developed as science policy became economically, and therefore politically salient. By 1990 a corporatist superstructural subgovernment was located within one of the most powerful central agencies of the Australian political system: the Department of Prime Minister and Cabinet.

4.1 The sectoral subgovernments

Science policy in 1965 was formulated and implemented by a set of sectoral subgovernments concerned with controlling the structures, ideas and resources of the parts of the science system in which their interests lay. These subgovernments were composed principally of scientists who decided the objectives of the science system (defence excepted) and oversaw the organisation of scientific activity. Only in the

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47 These and many other associations are listed in The Scitech Technology Directory compiled by Jane Ford.

48 Ripley, & Franklin, 'The Nature of Policymaking in the United States', p. 53.

rural sector was there any user involvement in these issues. There was no overarching mechanism for intersectoral co-ordination.

4.1.a Higher education

The participation of the higher education scientific community in science policy relates to the two broad functions of the higher education system in the production of scientific knowledge: namely, the conduct of research and the training of scientists. In 1965 the Minister-in-Charge, Commonwealth Activities in Education and Science received advice on research in higher education from the Australian Universities Commission (AUC) of which Sir Leslie Martin was Chair. From 1959 this agency had been responsible for Commonwealth government funding for universities and since 1961 had separated general funds from research funds.[49]

Although the Commission did not intervene in the selection of research areas by individual universities it exercised power through its control of the way in which the university system was structured and of the ideas underlying the organisation of research. Funds for research were divided between the AUC and the Australian Research Grants Committee (ARGC) in a ratio of 3:2.[50] Both the AUC and the ARGC had virtual autonomous control over the allocation of both human and financial resources for research: the ARGC on the basis of 'scientific excellence' to individual researchers and the AUC on the basis of 'comparative general level of postgraduate activity' to individual universities. Within the universities the funds were usually distributed by autonomous Grants Committees.

The allocation of funds was subject only to Ministerial approval with both agencies reported directly to the Minister. The AUC had a prescribed role in advising the Minister on science policy issues within the higher education system; the ARGC considered that it did not, professing a steadfastly traditional attitude of scientific political neutrality and organisational autonomy. Fraser, as Minister for Education and Science in 1969, was unsuccessful in trying to persuade the then Chair of the ARGC, Rutherford Robertson, that 'the national interest' should be included as one of the criteria for successful grant applications.[51] The situation was one of clientele pluralism in which the state is dependent on the skills and expertise of organised interests. The ideology of the science system prevailed over techno-economism in the rules governing university research.

4.1.b Higher education in transition

Until 1987 there were two predominant characteristics of the subgovernment of higher education research policy. The first was the stability of the structures of policy-making in the sector. The second was the division of responsibility for research in the

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49 Ibid., p. 353.
50 Australian Universities Commission, *Third Report,* Parl. Paper 330, Canberra,1964-66, p. 66.
51 Johnston & Buckley, 'The shaping of contemporary scientific insitutions', p. 387.

universities between the agencies of higher education administration and smaller, isolated granting systems. The situation changed in 1987 with the establishment of the Australian Research Council as the principal agency of higher education research policy and a concomittant re-organisation of the rules and resources of research.

In 1972 the Department of Education and Science was divided into two separate departments and responsibility for higher education research was split between two portfolios. The AUC became part of the Department of Education and the ARGC became part of the Department of Science. The ARGC continued to demonstrate an explicit, reactive rather than proactive pursuit of excellence across all disciplines despite a 1974 OECD recommendation that the ARGC should take a more proactive role in identifying certain fields of science for 'special care and concentrated financing'.[52, 53]

The proposed widening of the functions of the ARGC to include policy advice on areas of research priority was not implemented by the Fraser governments. Instead other agencies were beginning to develop policy initiatives in the higher education research system. The AVCC and CSIRO, prompted by the tightening of resources in 1976, were echoing the call of the OECD Examiners that there should be more co-operation between research organisations in both the public and private sectors in the use of resources for research. In 1977 the AVCC announced in a submission to ASTEC that it had proposed the establishment of a joint committee with the CSIRO Executive to, among other concerns: '...consult with ASTEC in advising government on major aspects of science policy'.[54] The committee never achieved government recognition and the subgovernment functioned 'in virtual isolation' from other government agencies until 1986.[55]

This allowed the ARGC to continue its policy of scientific autonomy and to sidestep ministerial pressure through such statements as the following:

> The ARGC considers it has a relevant advisory role to play in assisting the government to pursue its policies. This role is expressed directly in its statement on research strength among applicants from Australia's tertiary institutions.[56]

Another indicator of the ARGC's apolitical ethos is its passive role in the establishment of the Key Research Centres in 1982. In 1979 Johnston noted the rigidity of the institutions for the allocation of resources to science and suggested that some funds should be set aside by the ARGC or the CTEC for the promotion of

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52 With the exception that, in 1972, Fraser, as Minister for Education, had for the first time directed the ARGC to allocate a small amount of the triennial funds to 4 priority areas of research.

53 OECD, *Examiner's Report on Science and Technology in Australia,* 1974, p. 31.

54 ASTEC, *Science and Technology in 1977-78,* vol. 1A, p. 86.

55 Marshall, 'Bureaucratic Politics and the Demise of the Tertiary Education Commission', *Australian Journal of Public Administration,* vol. XLVII, no. 1, March 1988, pp. 19-34 , p. 20.

56 ARGC, *Report on Grants Approved for 1985,* Parl. Paper 123, Canberra, 1984, p. 6.

excellent mission-oriented science.[57] In 1981 a Commonwealth Centres of Excellence Research Committee was set up and advised the Minister that ten Centres of Excellence should be established and administered not by the ARGC but by the University Council of CTEC under the Commonwealth Special Research Centres Program.[58]

The higher education science policy subgovernment in 1983 was therefore divided both between agencies and over control of the ideology of scientific excellence. It was loosely integrated with other science policy subgovernments through informal networks and the co-membership of key agencies. These agencies formed a spectrum of influence and control of the system from the broad, highly political macro-level actions of ASTEC, through to the narrow scientific expertise and funding influence at the micro-level interactions of the ARGC sub-committees.

The incoming Hawke government decided to restructure higher education research. The re-organisation of the ARGS scheme was foreshadowed in comments by the Minister for Education at the review meeting of the OECD Examiners in Canberra in 1985, despite the opposition of researchers who favoured the current pluralistic system of funding.[59] In May 1985 ASTEC responded to a government request for advice by recommending that higher education research funding should be more direct, should be increased by at least 25 per cent, and should be co-ordinated into one statutory agency which should report directly to the Minister for Science.[60]

In 1986 the ARGC was restructured into the Australian Research Council (ARC); in 1987 the ARC became part of the Department of Education, Employment and Training; and in 1988 CTEC and the binary system of higher education in Australia was abolished and re-organised as the National Board of Employment, Education and Training (NBEET) and the Unified National System. CTEC had lobbied the Minister for Education to have the ARC as a standing committee within its own structure, but this was vigourously opposed by DITAC and Finance who wished to gain control of the ARC funds and who branded CTEC as incompetent in the allocation of research funds.[61]

NBEET is not a statutory authority and has an advisory rather than a managerial role. ASTEC had not recommended any major changes to the system of administration in higher education but had simply advocated a more corporate style of management in order to increase the efficiency and accountability of the use of

57 R. Johnston, 'Political, Administrative and Policy Aspects of Science and Technology', in *Science and Technology for What Purpose?: An Australian Perspective,* ed. A.T.A. Healy, Australian Academy of Science, 1979, pp. 97-102, pp. 101-102.

58 Commonwealth Tertiary Education Commission, *Report for the Triennium 1982-84,* vol. 3, Parl. Paper 220, Canberra, 1982, pp. 72-73.

59 OECD, *Examiners' Report 1985,* p. 113.

60 ASTEC, *Improving the Research Performance of Australia's Universities and Other Higher Education Institutions*, AGPS, Canberra, 1987, pp. 5-11.

61 Marshall, 'Bureaucratic Politics and the Demise of the Tertiary Education Commission', p. 31.

research funds. In 1987 DEET released a Green Paper on the restructuring of higher education, and in 1988 this was followed by a policy statement claiming, on the basis of 600 written responses and numerous consultations, overall agreement with the basic objectives of the government for the higher education system.[62]

The decision of the Minister to re-structure the system has been explained by Williams as the result of the displeasure of the Expenditure Review Committee (ERC) over the public lobbying of CTEC for increasing funds at a time when the government wished to project an image of decreasing public spending;[63] and by Marshall as the result of bureaucratic ambition to control greater areas of policy resulting from the culture of corporate management introduced into the Commonwealth Public Service by the Hawke government.[64]

From a policy community perspective it is a classic example of the concertation of policy networks in which state decision-making is concentrated in a single agency for the sector. The capacity of the existing higher education subgovernment to negotiate the available rules and resources had served the autonomy-seeking ideology of the science system well. It also fitted the conservative ideologies of the Fraser government which was loth to establish new policy agencies. The gap between political rhetoric and policy reality appeared in the early 1980s when the demands of clientele and government exceeded the capacity of the ARGC to accommodate both. Consequently, the core executive exercised its power of veto and reduced the autonomy of the higher education subgovernment. The situation was not one of a state-led network because organised interests in the form of ASTEC were directly involved in policy formulation.

4.1.c CSIRO

CSIRO is not an analytical category in the same sense as 'rural industry' or 'manufacturing industry', but the importance of the Organisation in Australian scientific activity, and the concomittant influence of its senior scientists warrant its inclusion as a sectoral subgovernment of Australian science policy. What is under consideration here is the changing pattern of influence exerted by CSIRO on science policy rather than the scientific activities of the Organisation.[65]

In 1965 the administrative structure of CSIRO was that of a nine-member Executive, five of whom were scientists and one of whom was the Chair appointed by the Minister Assisting the Prime Minister in Education and Research.[66] The Chair

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62 Department of Employment, Education and Training, *Higher Education: A Policy Statement,* AGPS, 1988, p. 3.

63 Bruce Williams, The 1988 White Paper on higher education', *The Australian Universities Review,* vol. 31, no. 2, 1988, pp. 2-8, p. 7.

64 Marshall, 'Bureaucratic Politics', pp. 22-23.

65 The changing pattern of scientific activity in CSIRO is discussed in chapter 6.

66 D.T.C. Gillespie, 'Research Management in the Commonwealth Scientific and Industrial Research Organization, Australia', *Public Administration,* (Sydney), vol. 42, Spring 1964, pp. 11-31, p. 18.

was always the most senior CSIRO scientist: indeed, until 1989 all the Chairs (and later Chief Executives) of CSIRO had spent the majority of their careers within the Organisation.[67] The Chair of the Executive was also the Chair of the Advisory Council, a body of State representatives which advised the Minister on the role of CSIRO. The functions of the Executive were concerned with advising the Minister on the policy and work of the Organisation, and on the appropriation and allocation of funds necessary for that work. The powers and functions of the Organisation were concerned with:

- the conduct of research for the promotion of primary and secondary industry;
- the training of scientific research workers;
- the establishment and awarding of scholarships;
- grant-making for pure science;
- the recognition of research associations and the granting of monies to them;
- the collection, publication and dissemination of scientific information;
- the testing and standardisation of industrial scientific instruments.[68]

The Organisation, and in particular the Chair, therefore had considerable power over the conduct of research in Australia. The formal powers were strengthened by the underlying assumption that science could only flourish when unencumbered by the control of non-scientists. This principle extended to the selection and expectations of administrators. As Gillespie (himself an Assistant Secretary to the Executive) explains:

> In CSIRO the position of Chief must be occupied by a man who has himself established a reputation in scientific research and who is capable of determining scientific policies and appreciating the requirements and conduct of research. ...The Chief, therefore, has almost complete freedom to manoeuvre. If a new development is of such magnitude as to go beyond his resources, he has recourse to central office which, with the co-operation of the Treasury, maintains an equally flexible attitude to the overall vote.[69]

Similar ideas were expressed when the Chair of CSIRO, Sir Frederick White, responding to a suggestion by R. S. Parker that governments should plan research activities, made it clear that no such 'interference' had occurred during his term of office:

> We cannot proceed, of course, unless we have money and this involves the support of the Minister, so that his authority is concerned in that way in the first instance. As far as his requiring us to do something, all I can say is that the Ministers we have had have been rather sensible people. I don't think that there is one instance where the government has come along to us and said, we require you to do research in this field; it would of course be rather an odd thing for a government to do....[70]

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67 Within CSIRO the Chair was always referred to as 'the Chief'. This nomenclature was also adopted at divisional level where the most senior scientist was, and still is 'the divisional chief".

68 Science and Industry Research Act no. 13 of 1949, Section 9.

69 Gillespie, 'Research Management in CSIRO', pp. 19 & 30.

70 Sir Frederick White, 'Administrative Problems in the Development of Scientific Research', *Public Administration* (Sydney), vol. XXVII, no. 2, June 1968, pp. 113-140, p. 139.

Nor should private industrial interests be involved in directing the activities of scientists. In his 1964 Presidential Address to ANZAAS White had given his opinion that scientists were more capable than industrialists of deciding which scientific knowledge should be developed for economic production.[71] Casey had expressed similar views in 1948.[72]

The subgovernment of CSIRO in 1965 therefore consisted of a closed policy network of the type described by Coleman and Skogstad as concertation in which a long-established, single agency has a monopoly over decision-making in its policy arena, in this case the relationship between the science system and economic production. In concertation networks organised interests are similarly represented by a single association. The Chair of CSIRO had control of both the Organisation and its advisory body of organised interests and was subject to minimal ministerial scrutiny. In 1965 CSIRO dominated the non-military, non-nuclear, science system in Australia and through its statutory obligations controlled the research - economy interface.

4.1.d CSIRO in transition

In 1966 the CSIRO Executive moved from Melbourne to Canberra in order to be closer to the processes of government, but, paradoxically, its influence in science policy was to be diluted by changing ideology in both the political system and the science system.[73] The AAS was proposing an independent advisory committee which would challenge CSIRO's dominance of resource allocation in scientific activity. In response CSIRO continually disrupted efforts to consolidate opinion in the preparation of a Cabinet submission on the issue:

> Throughout the development and extensive consultation processes associated with the preparation of a cabinet submission, CSIRO consistently sought not so much directly to oppose as to use the full range of bureaucratic techniques to divert, refer back, and seek wider consideration.[74]

In order to force some degree of co-operation within the subgovernment Fraser sent the Secretary of the Department, (later Sir) Hugh Ennor and the Chair of CSIRO to Europe together on a mission to collect information about governmental science policy machinery.[75]

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71 White, 'The Strategy of Australian Science', p. 194.

72 He speaks of:

> ...giving well-equipped scientific workers freedom to roam at will over the spheres in which they have specialised, so enabling them to extend the frontiers of their sciences in every direction that promises new knowledge.

Casey, *Double or Quit*, p. 47.

73 Ironically, Shedvin sees the move as the beginning of the end for the 'golden age of scientific autonomy',
Schedvin, 'The Culture of CSIRO', pp. 86-87.
In August 1992, the Chairman of CSIRO, Professor Adrienne Clarke, announced that CSIRO headquarters would be moving back to Melbourne.

74 Johnston & Buckley, 'The shaping of contemporary scientific insitutions', p. 386.

75 Ibid., p. 388.

Whitlam, through his political rhetoric of the late 1960s, upheld the role of CSIRO in science policy formulation. CSIRO would be a member of an Australian Science Council as well as acting as an 'operational' organisation acting autonomously to implement policies formulated by the Council.[76] However, when the ALP formed the government in 1972 responsibilty for CSIRO was placed with the Minister for Science, William Morrison, who was not a scientist and had taken no part in writing the ALP science policy.

The CSIRO Executive baulked at having to interact with a junior Minister, but took even greater exception to having to negotiate with the Minister through Secretary Ennor even though he was a scientist. Morrison recounts:

> Then we had CSIRO which for long time had been an authority unto itself and I don't think that they were all that keen on having a Department of Science, and certainly there were a lot of difficulties in bringing them into the relationship. They didn't want to work through the Secretary of the time and that was OK and so they reported directly to me and I kept both sides informed.[77]

Morrison found himself between CSIRO: '...which [was] an enormously competent piece of political bureacracy not terribly anxious to have a review' and the Department of Science which he described as 'failed scientists and incompetent bureaucrats'.[78] He wanted a source of information and advice about science policy independent of CSIRO. Australia had just become a member of the OECD and Morrison's solution was to call in the Science Division of the OECD as a neutral observer and to commission a report on public sector research and development as part of the Royal Commission on Australian Government Administration (RCAGA).[79]

The OECD Examiners' Report and the Report of the Science Task Force of the RCAGA were the first external reviews of CSIRO's role since 1948. The Science Task Force recommended that the Executive of CSIRO should be allowed greater flexibility in formulating science policy:

> Accordingly, we recommend that the Executive be reduced to three full-time and two part-time members; and that the structure of CSIRO be decentralized so as to leave the Executive free to concentrate on projecting (in consultation with ASTEC and other appropriate bodies and individuals) the scientific needs of the nation, deciding CSIRO's part in meeting these needs, coordinating and allocating resources accordingly and maintaining standards.[80]

The Science Task Force's Report was released shortly before the election of the Fraser government in December 1975 and Fraser decided that a more complete

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76 Whitlam, 'A National Science Policy', p, 135.
77 Morrison, Interview, 8th November 1989
78 Ibid..
79 Ibid..
80 RCAGA, Science Task Force, *Towards Diversity and Adaptabilit,y,* p. 61.

investigation of CSIRO's role in Australian scientific activity was required.[81] The ensuing Birch Report recommended enlarging the Executive; separating the Chairship of the Executive and the Advisory Council; and strengthening the role of the Advisory Council in order to make CSIRO researchers more responsive to user needs. The Report also recommended that: 'CSIRO should not include in its role the obligation to provide advice to government on broad scientific and technological policy'.[82] However, the Report did recommend that the relationship between CSIRO and Commonwealth government departments should be more formally structured to enable a better fit between CSIRO programs and government policies.[83] The ensuing re-organisation was gradually implemented over several years.

The next major change for CSIRO occurred as a result of the 1985 OECD Review of National Science and Technology Policy. The Examiners criticised CSIRO for continuing:

- a bias to basic research;
- a bias to rural research;
- a tendency to avoid interaction with other institutions;
- encouraging researchers with an orientation to science in general rather than to the benefits their work could produce for Australia.[84]

While none of these criticisms relates directly to science policy-making, the fact that they were still relevant eight years after the Birch Report indicates an unwillingness by the CSIRO subgovernment to implement the policy objectives of the Fraser and Hawke Governments. The solution proposed by the OECD involved the corporatisation of the CSIRO Executive. This was seconded by ASTEC which recommended the creation of an Executive Board with eight Directors and a part-time Chair.[85] The head of the Organisation was to be a Chief Executive with experience outside CSIRO, and the heads of the industry-sector-oriented Institutes were to be given the status of Directors with the concomittant financial responsibilities.[86] These changes indicate a shift in the type of policy network from concertative to corporatist

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81 He commissioned a Professor of Organic Chemistry at ANU; a former Chairman of the Melbourne Stock Exchange; and the Chairman of Comalco and Hammersley Holdings to undertake an independent inquiry into CSIRO.
Australia, Independent Inquiry into CSIRO, *Report,* August 1977, p. 146.

82 Mozley Moyal disagrees with this interpretation. Reporting the changes to the CSIRO Executive she says:

> However, it will no longer perform its historically accepted function of providing advice to Government on broad scientific and technological policy - a role now seen as devolving on the broad national shoulders of the Australian Science and Technology Council.

Mozley Moyal,'The Effect of Institutional Evolution on Science Policy', p. 71.

83 Ibid., p. 150.

84 OECD, *Reviews of National Science and Technology Policy: Australia,1985,* p. 52.

85 ASTEC, *Future Directions for CSIRO,* AGPS, Canberra, 1985, p. 8.

86 The actual structure was designed by McKinsey Associates.
Keith Boardman, 'Changes in R&D: too far or not enough?, Paper presented to the ANZAAS Centenary Congress, University of Sydney, 1988.

as non-government actors were co-opted by the government to ensure the implementation of subgovernmental strategy for CSIRO.

In 1986 the Science and Industry Research Act 1949 was substantially amended without specific statutory definition of a policy role for the Organisation. In 1988 the Minister for Science, who had retained portfolio responsibility for CSIRO within DITAC, issued a set of eleven guidelines under Section 13 of the Science and Industry Act. The guidelines effectively determine that CSIRO's function is to conduct research in accordance with the priorities of the government and to ensure effective use of its resources. There is no mention of the provision of advice on science policy to the government.[87] In 1990 the science portfolio was moved into the Department of Prime Minister and Cabinet but CSIRO stayed in DITAC illustrating the shift to an industrial focus for the Organisation and accentuating its loss of influence over science policy.

Thus one of the major transitions in the organisation of science policy between 1965 and 1990 has been the displacement of CSIRO as the principal actor within the science policy community. From its position of de facto predominance the Organisation is now the *primus inter pares* of research organisations and its role in deciding the direction of research in Australia has been diminished by the advent of a multiplicity of advisory agencies. The transition was only achieved when there was a fit between political ideology in the form of government objectives for the science system and the political will to restructure the Organisation, despite the influence of the CSIRO subgovernment.

4.1.e Manufacturing

In the early 1960s the Menzies Government's attitude to research in manufacturing industry was classically *laissez-faire*. Decisions about research directions for manufacturing industry were left to CSIRO divisional chiefs, the leaders of industrial firms, and scientists in universities who sometimes undertook research funded by local industries. Industrial leaders generally preferred to lobby government for tariff protection rather than for innovation subsidies.[88] This began to change in 1965 as the government came under pressure from industry to subsidise research in manufacturing industry.

The most significant actors in the manufacturing industry science policy subgovernment were The Institution of Engineers, the Australian Industry Research Group (AIRG) the Industrial Research Study Group (IRSG), the Minister for Trade and the Treasury. In 1963 the Institution, not the government, had appointed a Research and Development Committee to assess the research needs of manufacturing

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[87] CSIRO, *Annual Report 1987-88,* CSIRO Public Affairs, Canberra, 1988, p. 10.
[88] Nevile, *The Disaster of Private Sector Research and Development in Australia,* p. 6.

industry in Australia.[89] Similarly the IRSG was established by sectors of manufacturing industry concerned about the lack of innovation and the need for information on the issue of research in manufacturing industry. These two groups interacted with the Manufacturing Industries Advisory Council (MIAC) - an agency established by The Department of Trade to advise on ways of developing manufacturing industry in Australia.

The MIAC commissioned a survey of businesses to find out what research was being done, what barriers existed and how government could help minimise the difficulties.[90] The MIAC recommended a 200 per cent tax deduction for research and development activity in private firms but this was vetoed by 'Treasury and Taxation authorities'.[91] The MIAC's recommendation was endorsed by the Vernon Committee which received submissions recommending tax concessions from both the MIAC and the IRSG.[92]

The Holt government decided to act on the advice of Treasury rather than the manufacturing subgovernment of the science policy community (a nice example of the influence of the executive core - see section 5 below) and in 1967 introduced a grants scheme instead of an incentive scheme based on tax deductions. The scheme was administered by a Board of three and an Advisory Committee consisting of four private sector representatives and four managers of public sector research agencies. The Act stipulated that the Chair of the Board must always be from the private sector. The MIAC had continuing influence through its Chair, Sir James Vernon, who was consulted by Fraser, as Minister for Science and Education, over the composition of the proposed Advisory Council on Science and Technology, and who was a member of the Australian University Commission.[93]

In 1965 the manufacturing industry subgovernment consisted of policy networks in which sectoral interests existed in a weak associational system. An autonomous state, in the form of the Commonwealth government, had traditionally chosen not to impose a defined policy upon the weakly-organised interests assuming a policy advocacy role.[94] The policy network was therefore one of pressure pluralism.

4.1.f Manufacturing in transition

In the 1970s manufacturing industry research came under increasingly intense government scrutiny as the fall in commodity prices and the Whitlam Government's tariff policies highlighted the deficiencies of industrial innovation in Australia. Organised interests in the scientific community outside CSIRO and the AAS began to

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89 L.P. Coombes, 'Research and Development in the Manufacturing Industries of Australia', *The Journal of The Institution of Engineers,* vol. 37, no. 6, June 1965, N40-N44.

90 Peter Stubbs, *Innovation and Research,* F.W. Cheshire, Melbourne 1968, p. 173.

91 Coombes, 'Research and Development in the Manufacturing Industries of Australia', N43.

92 Australia, Committee of Economic Enquiry, *Report May 1965,* p. 425.

93 Johnston & Buckley, 'The shaping of contemporary scientific insitutions', p. 388.

94 Coleman & Skogstad, *Policy Communities and Public Policy in Canada,* pp. 27-29.

question the relevance of scientific work undertaken by government research establishments. Leading scientists in such firms as BHP and ICI Australia openly criticised the MacMahon government for its lack of action.[95] The Whitlam government initiated examinations into the issue by the OECD and a special Science Task Force of the Royal Commission of Australian government Administration.[96] The two enquiries, while disagreeing widely on the normative criteria for optimal relations between government and industry in science, agreed that more government research should be contracted out to private laboratories in order to enhance industrial interests' appreciation of the benefits of domestically-generated innovation over the importing of technical know-how.[97]

The Fraser government was in power by the time that the findings of the Reports had been digested by the science policy community. Fraser, as a former Minister for Education and Science, was familiar with the policy arena and its issues. He chose to restructure the existing incentives scheme rather than to change the relationship between the public and private sectors of the science system. The new Australian Industrial Research and Development Incentives Scheme (AIRDIS) operated from 1976 to 1986 and was unusual at the time because the legislation included a 'sunset' clause which required review of the scheme after five years.

However, the revamped scheme was not effective. The 1977 ASTEC Report found that research in manufacturing industry had diminished due to lack of government incentives. Again the Fraser government's response was an ad hoc expansion of the AIRDIS scheme, and a shuffling of portfolio responsibility for manufacturing research and development.[98] It was not until 1980 that AIRDIS was brought into the same portfolio as CSIRO, and therefore under the same

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95 See, for example, L.W. Davies, 'Federal Policy for Industrial Research And Development in Australia', *Search,* vol. 3, no. 11-12, November-December 1972, pp. 423-426, p. 425;
Ward, R.G. 'Science and Industry', *Search,* vol. 3, no. 4, October 1972, pp. 371-375, p. 374;
W.I. Whitton, 'An Industrialists's View', *Search,* vol. 3, no. 6, June 1972, pp. 212-216, p. 215.

96 OECD, *Examiner's Report on Science and Technology in Australia;*
RCAGA Science Task Force, *Towards Diversity and Adaptability.*

97 The OECD Examiners found that:

> ...as a rule the contacts between these three sectors are still only sporadic and often confined to personal relationships (p. 22)....barriers of a cultural or psychological nature [exist] between the academic world and the world of industry.

Whereas the Special Task Force quoted from a recent UK Science Research Council Report and offered their endorsement:

> "...success (in collaboration) depends strongly on the compatibility of the individuals in contact, and their enthusiasm for the project. Clearly defined objectives and responsibilites are important, but rank second to satifactory human relationships."...We agree.In our experience of collaborative activites, personal relations between individuals are of the essence (p. 79).

98 From its inception in 1967 until 1983 the scheme was administered by the following portfolios:

• Trade and Industry	67-72;
• Secondary Industry	72-74;
• Manufacturing Industry	73-75;
• Industry and Commerce	75-76;
• Productivity	76-80;
• Science and Technology	80-83.

subgovernmental influence.[99] The then Minister for Science and Technology, Brigadier David Thompson, was 'increasingly influential in a quiet way' in the portfolio by organising seminars between industry leaders, department officials and scientists about the process of innovation.[100] Nevertheless, he put the onus firmly back onto industry to take the initiative in producing scientific knowledge for innovation.[101]

Thompson also increased the size of the AIRDIS Board from five to nine members (all new members being industry representatives), widened the powers of the Board to include advice to the Minister and public relations with the industrial research and development community, and gave the Board responsibillity for inter-departmental co-operation in manufacturing research. These changes were implemented against a background of almost continuous enquiries into technological and scientific activity in Australia.[102] Against such a barrage of demands for action some changes were wrought, but in a way befitting the conservative political ideology of the Fraser government: that is, by minimising the establishment of new agencies of science policy for manufacturing industry, and re-structuring the existing agencies, particularly the advisory councils.[103]

The election of the Hawke Labor government in 1983 was on a Party Platform which included 67 propositions about the way in which scientific knowledge should be produced and used in manufacturing industry Australia. The 13 guiding policy principles included the promise of a 'pluralist approach' to deciding between 'old' and 'new' industries and declared that: 'Major decisions should be made after considerable public debate and not left to expert, professional elites operating in isolation.'[104] In the manufacturing industry sector this principle was effected by convening a National Technology Conference;[105] by establishing a Public Relations Committee as part of

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99 An indication of the perceived separateness of CSIRO from science and technology policy is that, despite comprehensive descriptions of such research agencies as the Antarctic Division and the Bureau of Meteorology, which were now included in the Department of Science and Technology, the *Annual Report 1980-81* contains no reference to CSIRO beyond a marked box on the organisational flowchart.

100 Neville Hurst, 'Government Science Policy: Future Directions and Lessons from History', Paper given at the University of Melbourne, 4.6.85, p. 6.

101 Department of Science and Technology, *Science and Technology Statement 1980-81,* AGPS, Canberra, 1980, preface (no page number).

102 The 1985-86 AIRDIB Annual Report lists 10 significant reports between 1978 and the fall of the Fraser Government in 1983. They are:

1978, 79, 80 & 83	various ASTEC Reports;
1979	Auditor-General's Audit of AIRDIS;
1979	Crawford Study Group on Structural Adjustment;
1979	Senate Standing Committee on Science and the Environment;
1980	Committee of Inquiry into Technological Change in Australia;
1980	Newton, Johnston & Smythe, *The Effectiveness of Government Support for Australian Industrial Research and Development;*
1983	IAC Report on Certain Budgetary Assistance to Industry;

Ibid., p. 13.

103 Johnston, 'Australian Science Policy: Now we can steer, where do we want to go?', p. 21.

104 Australian Labor Party, *Platform, Constitution and Rules*1982, pp. 147-148.

105 Policy ideas emerging from the National Technology Conference are discussed in chapter 3.

the AIRDIS structure; by appointing as AIRDIB Chair an expert in management; and by re-defining the role of the Board.

After the National Technology Conference of 1983 the Department of Science and Technology circulated a Draft Technology Strategy incorporating the whole spectrum of activities in science and technology from basic research to the provision of venture capital.[106] The National Technology Strategy was acclaimed by Sir Gustav Nossal, in his 1984 ANZAAS Presidential Address, as 'one of the most significant and courageous statements to come out of Canberra on any topic in the last decade'.[107] Other elements in the science policy community saw it as a 'pragmatic compromise between the major power brokers in Australian society' which would simply channel research and development funds to the most influential organisations in industry.[108] One of the outcomes of the Conference was the establishment of the Australian Industry and Technology Council as a forum for Federal and State Ministers of Science and Technology. The Council was modelled on the Agricultural Council and served by a Standing Committee on Industry and Technology.

The AIRDIS scheme became the main implementation agency of science policy for the manufacturing industry sector. For the first year of the new government the scheme was part of the Department of Science and Technology under Jones, but in 1984 it was moved to DITAC. Before the portfolio change Jones had widened the industrial scope of the Board to include two experts in the 'new' biotechnology-based industries - Sir Gustav Nossal of the Walter & Eliza Hall Institute, and Dr. Alexandra Pucci, the founder of Australian Monoclonal Development Pty. Ltd.. He also gave the Board much greater autonomy to advise not only the government but also industry on areas of priority in manufacturing industry research.[109]

The move to DITAC coincided with the second sunset review of the scheme. The Board held public meetings in all the mainland capital cities and conducted a survey of the scientific community and industry to elicit the opinions of the 'producers' and 'users' of research in manufacturing industry and concluded that the existing AIRDIS scheme was not fulfilling the requirements of this consituency.[110]

The new Grants for Industry Research and Development (GIRD) scheme extended the powers of the Board even further to include the issue of collaboration between research organisations 'including those in academe and industry'.[111] In this way the Board was given the authority to influence the conduct of research, not only

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[106] Anon, 'The Draft Technology Strategy', *Search,* vol. 15, no. 5-6, June/July 1984, p. 141.
[107] Sir Gustav Nossal, 'The Horizons of Science', *Search,* vol. 15, no. 7-8, August/September, 1984, pp. 214-216, p. 214.
[108] R. J. Badham, 'The National Technology Strategy: What degree of Public Choice?', *Search,* vol. 15, no. 7-8, August/September, 1984, pp. 198-199.
[109] Australian Industrial Research and Development Incentives Board (AIRDIB), *Annual Report 1983-84,*Parl. Paper 121, Canberra, 1984, p. 3.
[110] AIRDIB, *Annual Report 1984-85,* Parl. Paper 431, Canberra,1985, p. iii.
[111] Iindustry Research & Development Board (IR&DB), *Annual Report 1986-87,* Parl. Paper 74 Canberra,1988, p. 56.

in public sector research organisations, but also in the higher education research sector.

By 1989 the GIRD scheme was the linchpin of the manufacturing science policy network but it was a network which did not have a peak co-ordination council performing the same function in manufacturing industry as the Primary Industry and Energy Research Council does in rural industry research (see 4.3 below). There existed only indirect liaison through the representation of senior DITAC officials on the Australian Industry and Technology Council and its Standing Committee; and through the Australian Manufacturing Council and the associated advisory Industry Councils to all industries in the manufacturing sector. Responsibility for the formulation of policy was vested in the Science and Technology Policy Branch of DITAC which was responsible both to the Minister for Industry, Technology and Commerce, and to the Minister Assisting the Prime Minister on Science.[112]

The transition in the manufacturing subgovernment has therefore been from a situation in which pressure pluralist policy networks of an autonomous state interacted with separate policy advocacy groups, to one of clientele pluralist networks in which the state has deliberately co-opted the skills and expertise of organised interests to participate in the policy process. The move to corporatism has not yet been made. Suggestions of a levy-based system of research funding similar to that operating in the rural sector have not been taken up by governments because manufacturing interests have claimed that such a scheme would be unworkable in the climate of domestic competition which exists in manufacturing industry in Australia. Organised interests therefore remain relatively weakly associated.

4.1.g Rural

The subgovernment for rural research policy has traditionally been the most highly organised of all sectors. The economic importance of maintaining the international competitiveness of rural exports has been a significant factor in the development of a subgovernment closely integrated with its attentive public through a strong associational system of rural research funds, and capable of ensuring the participation of producers in central decision-making agencies.

A group who had significant influence on rural science policy were the producers' representatives on rural commodity and industry research committees.[113] Both their financial contributions and their demands on scientists could be substantial. For example, in 1965, 74 per cent of all non-Treasury contributions to CSIRO came from the Wool Research Trust Fund.[114] The 1957 Wool Research Act allowed two committees to advise the Minister on the allocation of research funds: the Wool Production Research Advisory Committee and the Wool Textile Advisory Research

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[112] Rymer, Interview, 30.4.90.
[113] A fuller account of the activities and funding is given in chapter 5.
[114] CSIRO, *Eighteenth Annual Report 1965-66,* p. 219.

Committee. Each committee had a fixed proportion of scientists, producers and public servants. Members of the Wool Textile Advisory Research Committee in particular exercised considerable power over which research would and would not be undertaken. The Wool Marketing Committee of Enquiry (the Philp Committee) found that:

> The woolgrower members, who together form the majority of the Committees have expressly or impliedly dictated certain fundamental policies, an important result being that the CSIRO has done little work on the effects of blending wool with man-made fibres. Many woolgrowers have an almost fanatical aversion to recognising that a textile composed of a blend of wool with man-made fibres has any value. It is this attitude which, in part, has prevented the CSIRO from undertaking research into blends.[115]

These producers had a considerable effect, through the mechanism of advisory committees, on the direction of research in such public sector organisations as CSIRO and the laboratories of State departments of agriculture. Furthermore the producers were deliberately manipulating the rules under which the trust fund operated. The Philp Committee found that, although the Wool Research Act allowed the representation on the research advisory committees of persons skilled in textile production, all the relevant membership allocations were occupied by woolgrowers.[116] The producers exercised their economic and political power to control membership of the key resource-allocating committees despite the chairmanship of the Deputy Secretary of the Commonwealth Department of Primary Industry and the presence of of the Chair of CSIRO as a member.

There were opportunities of overlapping membership which provided considerable potential influence on the direction of research effort. A university science professor could be a member of the Australian Universities Commission, the CSIRO Advisory Council, a CSIRO State Committee, the research advisory committee of an industry research trust fund, and also participate in the executives of ANZAAS and the AAS. For example, in 1965 Sir William Gunn, Chair of the Australian Wool Board and member of both the Wool Production Research Advisory Committee and the Wool Textile Research Advisory Committee, was also on the State Committee of CSIRO in Queensland.[117]

The combination of strongly associated industry representation with considerable control over financial resources and the membership of subgovernmental advisory agencies indicates a policy network in rural research in 1965 of the corporatist type described by Coleman and Skogstad. In this type of network multilateral

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[115] Committee of Enquiry into Wool Marketing, *Report,* Parl. Paper, 51, Canberra, 1962, p. 106, paragraph 584.

[116] Ibid., p. 106, paragraph 582-583.

[117] Australian Wool Board, *Annual Report 1965-66,* Parl. Paper 56, Canberra, vol. XIII, 1964-66, pp. 437-438.
CSIRO, *Eighteenth Annual Report 1965-66,* p. 176.

user/producer groups combine in a highly integrated associational system to negotiate conditions which will enable them to protect their interests. They are then co-opted by governments to cope with social or economic problems - in this case the maintenance of Australian rural export competitiveness. Government policy for the sector is implemented through the interest groups, in this case again through the rural research trust funds sponsoring research in the national interest.

4.1.h Rural subgovernment in transition

In the 1970s policy decisions for the organised but fragmented system of rural research funds were made by individual advisory councils consisting of scientists, producers and State and Commonwealth officials concerned with the wool, wheat, dairy, meat, chicken and dried fruit industries.[118] Major inquiries commissioned by the Whitlam and Fraser Governments eventually led to an overhaul of the system of rural research policy advice.[119] The Australian Agricultural Council and its companion Standing Committee on Agriculture, which had existed since 1929 but which had not participated to any great extent in the science policy process, were found wanting by the Industries Assistance Commission which recommended an additional agency for the co-ordination of rural research.[120] This advice led to the establishment in 1978 of a Commonwealth Council on Rural Research and Extension (CCRRE). The Council's role was to advise the Minister for Primary Industry across the entire spectrum of rural research in Australia. The Council was also, among other matters, to:

- develop interactions with all Commonwealth research agencies in order to co-ordinate rural research within other institutions;
- advise the Minister on the role of rural research in the Australian economy;
- ensure the practical application of research findings; and
- develop priorities for rural reseach.[121]

The Fraser government obviously perceived the need to co-ordinate policy-making and implementation for the production of scientific knowledge to be applied to rural economic production but not for manufacturing industry. Fraser's private status as a rural producer may have been influential in this issue. The Standing Committee on Agriculture resented the intrusion into its intergovernmental role and promptly established its own Advisory Committee on Priorities in Rural Research and Extension (ACPRRE) in 1980. However, the Councils proved ephemeral or redundant. The CCRRE was abolished in 1981 on the finding of the Commonwealth Review of

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[118] A more detailed account of the funding mechanisms of these industries is given in chapter 6.

[119] Australia, Working Group, *The Principles of Rural Policy in Australia: Report to the Prime Minister by a Working Group,* AGPS, Canberra, 1974.
Industries Assistance Commission, *Financing Rural Research,* Parl. Paper 155, Canberra, 1977.

[120] Ibid., p. 8.

[121] Department of Science and Technology, *Science and Technology Statement 1980-81,* AGPS, Canberra 1981, p. 59.

Government Functions that the Council duplicated functions of the States. ACPRRE survived until 1988 with little to show for its existence.[122]

The Hawke government revitalised the Australian Agricultural Council and the Standing Committee on Agriculture by re-affirming the roles and functions of the two agencies and increasing the frequency of meetings. Rural research policy became the responsibility of the Policy Development Branch of the Development and Co-ordination Division of the Department of Primary Industry, and also of the Bureau of Agricultural Economics which convened a national workshop on the organisation, funding and planning of research and the application of research results. Such workshops have become a regular feature of networking in the rural science policy community. The list of organisations represented by participants in the 1989 Workshop on Research Priorities and Resource Allocation for Rural Research and Development is an illustration of the science policy community in rural research in 1989:

- seven State & Territory departments of primary industry;
- the Wool, Wheat, Meat and Livestock, Egg, and Fish Research Councils;
- university agricultural science departments
- ASTEC
- CSIRO
- Australian Bureau of Agricultural and Resource Economics;
- Bureau of Rural Resources;
- Office of the Minister for Primary Industries and Energy;
- Department of Primary Industries and Energy;
- Department of Technology, Industry and Commerce;
- Department of Finance.[123]

At the Workshop the then Minister for Primary Industries and Energy, John Kerin, explained how the policy community had evolved:

> In the past we have recognised the right of fund providers, and of those conducting research, to manage their own affairs. As rural research has become more complex, with tight limits on total resources, as the numbers of interested parties increases and the demands of the system intensify, we should be able to influence the outcomes we expect by careful management.
> ...What I have just described to you could be represented as a grid of interests with vertical and horizontal connections. It is thus entirely appropriate to suggest at this point that we all give fresh consideration to networking, the activity through which we make all the necessary connections in our grid of interests.[124]

For example, the announcement in 1992 of reductions in the rural research levies on producers[125] (which means a concommittent reduction of government matching funds) was part of the rural research policy network consisting of relationships

122 Williams & Evans, 'Commonwealth Policy for Rural Research Past and Present: A Review', p. 108.

123 The Hon. John Kerin, Opening Address for Bureau of Rural Resources, *SCA Workshop on Research Priorities and Resource Allocation for Rural R&D*, Canberra, 2-3 November 1989, p. 6.

124 Ibid., pp. 4 & 6.

125 'Cabinet slashes rural grants', *Weekend Australian*, August 1-2 1992, p.1.

between the federal Department of Primary Industry and Energy; the State Departments of Agriculture; the various rural research development corporations; producer associations; the CSIRO, university research and private research laboratories; the Department of Finance; the Treasury and the Expenditure Review Committee of Cabinet. The corporatist subgovernment reacted collectively against a threat to its interests from the executive core.

The rural community, with its long tradition of collective action on research funded partly by producers and partly by government, is an integral part of the subgovernment of rural research. This has led to a system of interaction in which rules, ideas and resources of interaction have been generally decided jointly by the state, the producers and the scientists. The state provides the structures (rules and legitimacy) for producing the knowledge and gathering the levies, and also matches industry contributions which enhances economic production. The producers, who exist in a highly-integrated associational system of multi-lateral consumer/producer groups, are committed to funding new knowledge and technology. The scientists maintain a degree of autonomy from the state and can use the value of their contribution to negotiate working conditions which will bring them their ultimate objective of internationally-recognised scientific competence.[126]

5. The Executive Core

In chapter one the shortcomings of the policy community approach in explaining policy were discussed. The most problematic of these is the failure to distinguish a group of actors who do not participate regularly in the routine decision-making of science policy but whose concurrence is necessary for crucial decisions about the allocation of resources to science. This category of actors is designated the executive core in the modified policy community approach used in this thesis.

The concept of the executive core is based on the observation that, in analysing a particular policy using the policy community approach, it becomes apparent that the notion of subgovernment does not cover the entire field of action involved in policy-making. The approach is particularly problematic when discussing the role of central agency actors who participate only occasionally in decision-making about research. For example, Cabinet ministers with non -research portfolios would discuss resource allocation or restructuring of the science system; the senior officials of the Department

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[126] The tradition of preferring basic to applied research dies hard in the science system. The Chief of the Wool Technology Division of CSIRO recently wrote:

> The wool industry's approach to basic science is far-sighted and unique in Australia. All the more so when one has the opinion, as I do, that much of the basic research effort in Australia has been pursued out of personal preference rather than community need. Some of the most exciting fundamental breakthroughs I have been fortunate enough to witness have been developed by scientists working under pressure on very applied projects. Indeed many, if not most, of the great breakthroughs in science have sprung from minds addressing very tangible threats and opportunities in everyday life.

Ken Whitley, 'Wool in the Future', *Agricultural Science, New Series,* vol. 5, no. 2, March 1992, pp. 16-19.

of Prime Minister and Cabinet have influence through the portfolio agencies for research (see section 8.2 below); and the Treasurer or Minister of Finance certainly can veto the allocation of resources for policy implementation. These actors are officials and politicians who, although of central importance in the whole arena of government action, do not make routine or important decisions about particular policies. Their advice is not automatically sought in such issues but without their approval action on general issues could not occur.

5.1 The executive core in 1965

Because of the nature of Cabinet-level decision-making in Menzies' governments the executive core for science policy was virtually non-existent. Ministers brought their decisions to Cabinet for discussion and ratification. Their judgement in their policy arena was considered to be paramount.[127] In the science policy arena it was the Prime Minister himself who announced the major policy initiatives in Parliament. The Minister Assisting the Prime Minister in Science and Education sat in the Senate and made few, if any, policy speeches. The roles of the Treasurer and Senior Treasury officials would be confined to approval of budgetary allocations which, according to White and Gillespie, were usually perfunctory even when large projects were being resourced.[128] The fact that the CSIRO Executive later rebelled at Ministerial control suggests that overall Cabinet approval had never been a problem in obtaining resources.[129]

5.2 The executive core in 1990

In 1990 the process of central decision-making about the allocation of resources to science had enlarged to include the scrutiny of the Expenditure Review Committee (ERC) and the processes of program budgeting overseen by the Department of Finance. The executive core for the science policy community would therefore consist of the non-science portfolio members of the Cabinet and the ERC (including the Prime Minister, the Treasurer and the Finance Minister), and the Joint Committee of Budget Officials.[130]

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127 Sir John Bunting, *R.G. Menzies, a Portrait,* Allen & Unwin, Sydney, 1988, p.81-82.

128 White, 'Administrative Problems in the Development of Scientific Research', p. 139. Gillespie, 'Research Management in CSIRO', pp. 19 & 30.

129 Johnston & Buckley, 'The shaping of contemporary scientific institutions', p. 384.

130 The CBO is composed of public servants from the three co-ordinating agencies; the Departments of Finance, Prime Minister and Cabinet and the Treasury. The CBO advises the ERC on outlays and timetables for the Budget process. It also provides a forum for the discussion of broad fiscal issues between officials from departments with a special responsibility for economic management. The ERC and the CBO together account for the most significant interaction of the executive core of any policy community.
Christopher Higgins & David Borthwick, 'The Role of Central Agencies', in *Decision Making in Australian Government: The Cabinet and Budget Processes,* eds. Brian Galligan, J.R. Nethercote & Cliff Walsh, Centre for Research on Federal Financial Relations, ANU, Canberra, 1990, pp. 43-61, p. 50.

The ERC is guided in its decisions by the work of the Department of Finance which prepares detailed analyses of departmental outlays, potential areas of saving and new policy proposal costing. The Department of Finance also liases with Treasury in the production of forward estimates of the state of the economy. These forward estimates model the economic environment in which future government action will occur. Particular forward estimates are also passed on by the Department of Finance to each department to be used in the preparation of Budget Submissions.

The Department's functions are managed in divisions by branches which correspond roughly to portfolios.[131] There is no special branch with responsibilities for a science and technology budget. The control of the allocation of resources for scientific purposes is fragmented across departmental divisions in the same way that the research activities are dispersed among departments. The preparation of the Science and Technology Budget Statement is carried out by officials in the Department of Industry, Technology and Commerce.

The process of allocating resources includes the following steps:

- the Department of Finance issues forward estimates to departments on the assumption that there will be no policy changes;
- the ERC sets overall budgetary targets;
- ministers are asked to give an indication of prospective policy changes;
- the Department of Finance advises ministers on strategies to manage these policy changes;
- ministers are expected to suggest areas in which savings might be made;
- the ERC reviews savings and new policy measures on a portfolio basis and consults with ministers;
- Cabinet in plenary session considers ERC proposals in finalising the Budget;
- each Commonwealth government program is evaluated every 3-5 years.[132]

Department of Finance officials insist that the role of the Department is not to cut particular expenditure but to assist the ministers and staff of other departments in priority setting and evaluation procedures. This role inevitably brings the Department into conflict with researchers and program managers who may be unfamiliar with these procedures and who view them as unnecessary bureacratic additions to their professional activity.[133]

However, many examples have been given in the above discussion and in the previous chapter of how the executive core can influence science policy. The power of the Treasury to block a tax subsidy for manufacturing research was exercised during the Menzies, Holt and Fraser governments. The granting of such a subsidy in 1985 has to be seen as a major victory for the science policy subgovernment, but the

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[131] Ibid., p. 57.

[132] Stephen Bartos, 'Competing Demands for Commonwealth Funding - the effect on rural research and development', in *SCA Workshop on Research Priorities and Resource Allocation for Rural R&D,* Canberra, 2-3 November 1989, pp.47-57, p. 52.

[133] Ibid., p. 51.

subsidy is under continuing threat from Treasury which is partly responsible for its operation.

The executive core also can make fairly arbitrary decisions without notice to the subgovernment. For example in 1992 it was announced by press release that the Commonwealth government contribution to rural research funds would be changed from an almost universal dollar-for-dollar basis to one in which rural producers in certain industries would contribute a larger proportion than the government. This decision had been made in full Cabinet rather than by the Minister for Primary Industry and Energy. The ensuing media exposure forced the executive core to back down on its decision to force cutbacks in this way.[134]

6. The Superstructural Subgovernment

The above discussion illustrates the increasing complexity of the science policy process in Australia. Figure 4.3 summarises the changes which have taken place in the subgovernments in time segments corresponding to changes of government.

The continued separation of decision-making into functional sectors has severely constrained the development of a coherent set of objectives for the publicly-funded science system in Australia. This has suited the interests of many scientists who have resisted, in the name of scientific autonomy, the centralisation of science policy decision-making. For many years the need for co-ordination was also resisted by governments whose conservative ideology preached non-intervention. However, the need to co-ordinate the allocation of steady state or diminishing resources and the direction of research effort has resulted in the development of a set of techno-political agencies which straddle the sectors and attempt to co-ordinate research activity within them. This category of actors in the policy community is here called the ***superstructural subgovernment*** and the following section analyses the development and significance for science policy of these agencies.

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134 'Cabinet slashes rural grants', *Weekend Australian"*, 1-2 Aug. 1992, p. 1.

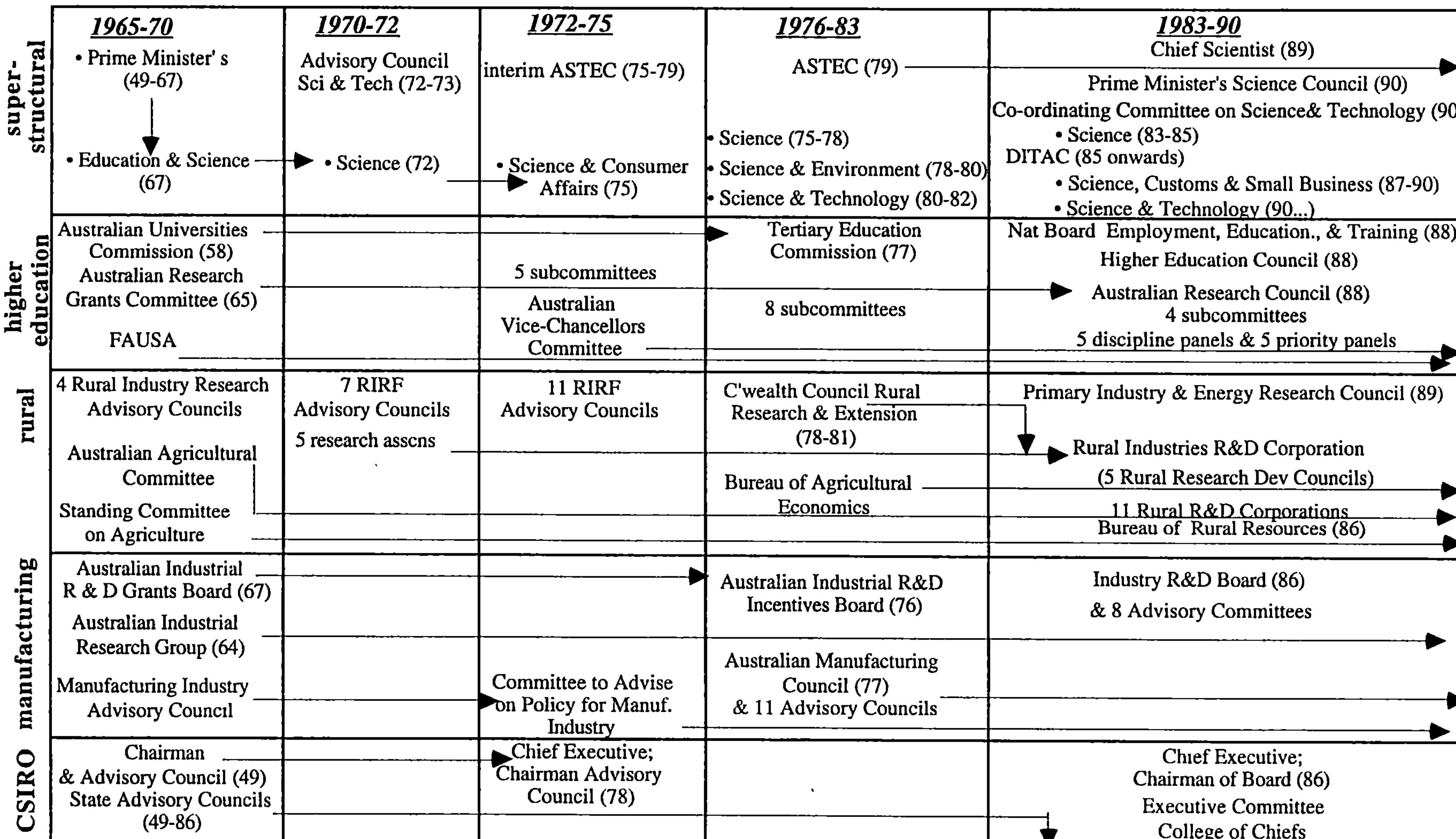

Figure 4.3: The science policy community, 1965-90

6.1 The superstructural subgovernment in 1965

In 1965 the superstructural subgovernment was rudimentary, consisting of the Prime Minister, who made important policy announcements (e.g., the establishment of a grants scheme for university research); significantly-placed individuals from each sectoral policy community interacting semi-formally or informally with each other or with the Prime Minister; and a Minister-in-Charge, Commonwealth Activities in Education and Science who assisted the Prime Minister on science policy issues. Menzies himself had held the portfolio in 1962-63 as 'Minister-in-Charge CSIRO', and from 1950-1960 R.G. Casey had been in the position.[135] Gresford wrote of the situation in 1965:

> So far, Australian moves towards any sort of centralized policy-making or advisory body for science policy have been indecisive. For many years ... the CSIRO has*de facto* filled this role to a certain extent.
> ...it [CSIRO] was for many years the dominant government scientific instrumentality in the country and the principal initiator of science policy.[136]

There was no statutory provision for the Chair, the Executive, the Advisory Council or the State Committees of CSIRO to proffer advice to governments other than that concerning CSIRO.[137] Senior CSIRO scientists were occasionally involved in Cabinet discussions on policy, but, according to Sir Frederick White, such matters were 'highly confidential' and had 'no effect on scientific activities' in the Organisation.[138]

For several years there had been some public airing of the idea of an overarching science advisory council but no formal moves had been made in that direction. The idea had been expressed by Oliphant in his 1958 ANZAAS Presidential Address but had not gained favour with Menzies.[139] In 1961 the Executive Commissioner of the Australian Atomic Energy Commission (AAEC) had suggested that there should be a Department of Government 'specially charged' with the definition of research policy

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[135] Johnston & Buckley, 'The shaping of contemporary scientific institutions', p. 379.
In 1948 Casey had outlined his vision for a post-war Australian economy based on research and overseas capital. Casey advocated a science system based on a network of industry research associations informed by a government research organisation undertaking basic research and international liasion. He saw the necessity for a planned research policy integrated with incentives for the expansion of secondary industry in Australia. He had used innovative management techniques such as 'Organisation and Method' and the industrial relations practices of Elton Mayo in his terms as Governor in Egypt and Bengal and had far-sighted views about the transformation of Australian industrial relations. However, Casey's ten-year term as Minister-in-Charge, CSIRO, is almost invisible in the Australian science policy literature. A possible explanation is that his plans for the science-based expansion of manufacturing industry in Australia were neutralised by the Country Party and its leader, McEwen.
Casey, *Double or Quit.*

[136] Gresford, *The Organisation of Science Policy in Australia,* pp. 11 & 15.

[137] Science and Industry Research Act, no. 13 of 1949.

[138] White, Administrative Problems in the Development of Scientific Research', p. 130.

[139] Oliphant, 'Science and the Survival of Civilization', p. 11.

and its operation.[140] In 1962 university researchers expressed similar views but preferred:

> ...an advisory council of strong and distiguished scientific-economic composition and with a suitable breadth of representation, reinforced by the nomination of a senior minister to convey its recommendations to Cabinet.[141]

By 1965 the idea of establishing such a council was expressed by Menzies himself in Parliament. According to Encel, Calwell, the ALP Leader of the Opposition, had used the idea in his 1963 Election Campaign.[142] Encel considers that Menzies' appropriation of the idea was not unusual:

> Neither the Menzies government, nor the Liberal Party at large, made any direct response to the ALP's espousal of science policy. On the well-established conservative principle of stealing the Whig's clothes, applied by Menzies throughout his political career, the Liberal government nevertheless moved step-by-step in the same direction.[143]

However, neither Menzies nor his successors Holt, Gorton or Fraser, acted to concretise the policy rhetoric of the proposed advisory council. Policy advice continued to come from individuals highly placed in the elite organisations of science.

One of these was Oliphant (later Sir Mark) whose influence in the organisation of science in Australia dates from 1945 when he had returned to the UK from his involvement in the development of the atomic bomb in the USA. He was subsequently 'head-hunted' by Coombs, appointed Head of the Research School of Physics at ANU, and co-founded the Australian Academy of Science (AAS). However, it was not only through these two agencies that Oliphant was influential. Cockburn and Ellyard speak of the '...close personal relationship' with Menzies which was '...exceptionally beneficial to science'.[144] Oliphant in return found Menzies' ideas about science '...fuzzy and very limited in scope', but was reassured by Menzies' opinion that 'the Treasury boys' should not interfere with the allocation of resources within the science system. These sentiments demonstrated to Oliphant

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140 A.D. McKnight, 'The Role of the Public Servant in Research', *Public Administration* (Sydney), vol. XX, no. 2, March 1961, pp. 139-163, p. 139.

141 Anon, 'Science in Australia', *Current Affairs Bulletin,* vol. 30, no. 7, August 13, 1962, pp. 99-112, p. 111.

142 No formal expression of the idea can be found in the offical *Federal Platform.*
Australian Labor Party, *Federal Platform, Constitution and Rules,* no. 1, (as amended by the 25th Commonwealth Conference, 1963), ALP Federal Secretariat, Canberra, 1964.

143 Encel, 'Pushing the barrow uphill', p. 27.

144 In 1948 he had written to Rivett, the then Chairman of CSIR, regarding the 'Red Scientist' scare:

> Would it not be wise to transfer all secret work and all contacts with secrecy from CSIR to the Supply Department and force them to set up a scientific organisation of their own? They could then revel in red stamps and stultify work to their heart's content and CSIR could be free!

In 1949 the defence work of CSIR was tranferred to the new Weapons Research Establishment and CSIR became CSIRO.[144]
Cockburn & Ellyard, *Oliphant,* p. 212.

that Menzies was 'with us'.[145] Oliphant's ideas about an autonomous science system fitted Menzies conservative political ideology of elites and they were united in their desire to withstand economic ideas about research from the executive core in Treasury.[146]

In addition to Oliphant, Mozley Moyal identifies five other influential scientists in this period all of whom were Fellows of the AAS. They were:

Sir Philip Baxter	Vice Chancellor of the University of NSW Chair of the AAEC
Sir Leslie Martin	Chair of the Australian Universities Commission Defence Scientific Adviser Chair of the Report on Tertiary Education Member of the AAEC
Sir Ernest Titterton	Director, Research School Physical Sciences, ANU Member, National Radiation Advisory Committee
Sir John Eccles	Professor, John Curtin School of Medical Research President AAS, 1957-61
Sir Macfarlane Burnet	Director, Walter & Eliza Hall Institute President, AAS 1965-69.[147]

They each interacted both individually and organisationally with Menzies. For example, Eccles personally negotiated with Menzies the knighthood conferred on Ellerton Becker after he donated £100,000 for the completion of the AAS building in Canberra.[148] Menzies appointed Martin Chair of the Commission on the Future of Tertiary Education which had recommended the establishment of a national science foundation to manage research grant funds and evaluate grant proposals.[149]

The CSIRO Executive, the AAS, a handful of senior academic scientists (particularly from ANU), and the Minister constituted a weakly associated policy network of the type described by Coleman and Skogstad as clientele pluralism. Governments were dependent on the scientists to run their particular sector of the science system and allowed them considerable autonomy. Outside this network the other sectoral subgovernments were small and fragmented. Medical research policy had been autonomous since the establishment of the NH&MRC in 1936. Defence policy had become the responsibility of the Department of Supply. It was the

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145 Ibid..

146 Professors Karmel and Melville regarded Oliphant's grasp of economics as: '...inadequate and dangerous in one with so much influence'.
Ibid., p. 326.
Crisp regarded Menzies' grasp of economic policy as 'less than deep-seated and fluctuating'.
L.F. Crisp, 'Central Co-ordination of Commonwealth Policy-making:Roles and Dilemmas of the Prime Minister's Department', *Public Administration* (Sydney), vol. XXVI, no. 1, March 1967, pp. 28-76, p. 38.

147 Ann Mozley Moyal, 'The Making of the Federal Government's Science Policy', in *The Pieces of Politics*,2nd edn., ed. R. Lucy, Macmillan, Melbourne, 1979, pp. 459-475, p. 465.

148 Ibid., p. 215.

149 Committee on the Future of Tertiary Education in Australia, *Report.*

scientists or scientist-administrators in the research organisations funded by the Commonwealth and State Governments who were responsible for establishing structures, setting priorities and making decisions about the application of research results.

6.1.a The superstructural subgovernment in transition

The patterns of change in the science policy process which began in 1965 accelerated as greater expectations of science developed to deal with the increasing complexity of government (science in policy) and the increasing centrality of science to national social and economic well-being (policy for science). Some of the changes were of long gestation when the political ideology of the executive core did not fit the demands of significant actors in the science policy community. Change was more rapid when political ideology was congruent with such ideas. Resulting structural changes often initiated counter-responses from members of the science system whose interests were most at risk. The most significant changes are illustrated by the changing portfolio responsibility for science and the establishment of a permanent advisory agency for science policy in 1977. The pattern of change is one of increasing institutional complexity within distinct functional sectors.

6.1.a. i Portfolio responsibility for science

There has always been a polarity of opinion within the science policy literature in general and the science policy community in Australia in particular, about whether portfolio responsibility for the production and use of scientific knowledge should be vested in a single ministry or divided among those portfolios with significant science agencies. Both Menzies and Hawke espoused the cause of science in their political careers and located the central agency of science policy-making into the Prime Minister's Department. Fraser placed ASTEC in the Prime Minister's Department but kept other agencies well-dispersed in order to be able to exert executive control over scientific activity. Whitlam used science policy as an electoral issue and advocated a separate Minister for Science and Technology who would have a co-ordinative rather than a directive role. The first Hawke government, with a science policy formulated by Jones, had a similar philosophy but later abandoned the idea in the face of opposition from the science system and the sectoral subgovernments.[150]

The separate science portfolio created by Hawke was subsumed into the Industry, Technology and Commerce portfolio in 1987. This continued a pattern of political and ideological expediency in the location of responsibility for science within the ministry. Only once, for the period 1967 to 1972, was responsibility for science

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150 Marshall, 'Bureaucratic Politics and the Demise of the Tertiary Education Commission', p. 20.

in one ministry for more than three years, and during this seemingly stable period there were five changes between four different ministers.[151]

For each science policy sector there have been different patterns of portfolio location. Rural science policy has always been in a department of primary industry and the Universities Commission has always been under the auspices of a department of education. The industrial research grants scheme has shown the greatest variety of portfolio location and nomenclature moving from Trade through Manufacturing Industry, Productivity, Science and Technology to Industry, Technology and Commerce. This variety illustrates the ambivalent attitude of Commonwealth governments to the seemingly intractable problem of the development of manufacturing industry in Australia, and the place of science in that development.

The pattern of portfolio responsibility for CSIRO is the most indicative of the changing attitude of governments to the production and use of scientific knowledge in national affairs. From the establishment of CSIR in 1926 until the quickening of interest in science policy in the early 1960s portfolio responsibility for CSIRO was isolated from any particular department and was of a nominal nature. The first departmental placing, in 1964 under a Minister for Commonwealth Activity in Science and Education, indicates that CSIRO and scientific activity was primarily seen as a non-industrial activity despite the overwhelming significance of rural industry interests in CSIRO at the time.[152] From 1967 until the fall of the coalition government in 1972 this part of the portfolio became a separate Department of Education and Science. This five-year period was the only time that ministerial responsibility for CSIRO and the higher education research system was vested in a single portfolio, but it was not until Fraser took over in 1968 that science came out of the shadow of education.[153]

Under Whitlam CSIRO was located within firstly, the Department of Science and then the Department of Science and Consumer Affairs. Both ministers were involved in organising change elsewhere in their portfolios.[154] In the Fraser Governments CSIRO was located in portfolios named consecutively, Science, Science and the Environment, and Science and Technology. It was not until 1987 that the Organisation was located, consistent with the increasingly predominant ideology of techno-economism, in the same portfolio as industry policy (Department of Industry, Technology and Commerce).

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151 The ministers were: Gorton (Feb. '67-Feb. '68); Fraser (Feb. '68-Nov. '69); Bowen (Nov. '69-Mar. '71); Fairbairn (Mar. '71-Aug. '71) and Fraser (Aug. '71-Dec. '72).

152 The internal allocation of funds in CSIRO in 1965 indicates that over 60% was for research connected with rural production. See chapter 5, p. XXX.

153 Johnston & Buckley, 'The shaping of contemporary scientific insitutions', p. 384.

154 Morrison was overseeing independence for Papua New Guinea.
Morrison, Interview, 8 November 1989.

6.1.a. ii A science policy advisory council

An advisory council for science policy, hinted at in Menzies' 1965 speech, and advocated by some organised interests, was established as a pre-election gambit by McMahon in 1972 to appease the growing chorus of criticism from industry and the scientific community at the Coalition's lack of purpose in science policy.[155] The membership of the Council was perceived by Whitlam to be weighted too heavily in favour of organised industrial interests and a temporary body was created to fit the ALP's platform on science. It was finally made permanent by Fraser in 1978 as the Australian Science and Technology Council (ASTEC).[156] From then until 1989 ASTEC was the major source of advice on science and technology policy for Prime Ministers. The Council has always been located in the Department of Prime Minister and Cabinet and reports directly to the Prime Minister.

The composition of the Council is primarily of representatives of industry and the universities. The first Council consisted of 15 members: seven were from the higher education reseach sector and five were from private industry. The remaining members consisted of a unionist and a political scientist specialising in science policy. There was no representative of CSIRO and the only representative of rural industry was the President of the Woolgrowers' and Graziers' Council.[157] In 1986-87 this composition had changed only slightly with eight members from the higher education research sector, six from industry and one union member. The Chairpersons have always been from the higher education sector. There is still no representative of CSIRO. Members are chosen by the Prime Minister on the recommendation of the Chair.[158]

ASTEC functions by preparing reports on topics suggested by the Prime Minister or by Council; by providing briefing notes for Cabinet; by advising on Budget proposals and by offering advice on science and technology issues which arise in different portfolios. Reports are prepared by working parties of ASTEC members and co-opted members with relevant skills and experience. Ministers are invited to the Council meetings of which there are usually eight a year. The agenda for each meeting is sent to all departments with a scientific component (15 in 1987); to the largest government research agencies (CSIRO, DSTO, ANSTO); to the Office of the Economic Planning Advisory Council; to CTEC (later NBEET); and to the Australian

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155 Mozley Moyal, 'The Making of the Federal Government's Science Policy', p. 471.

156 Although a major report on science and technology in Australia was produced by the interim ASTEC in 1977-78 the Australian Science and Technology Council Act was not passed until 1978 and the interim Council not made permanent until 1978.

157 ASTEC, *Science and Technology in 1977-78*, vol. 1A, AGPS, Canberra, 1978, p. vii.

158 Dr Alexandra Pucci, a member of ASTEC from 1987-1990 says:

> I couldn't tell you exactly how the nominations go through. Presumably there is a suggestion to the Prime Minister from the Chairman and others he takes advice from and then a recommendation for names. Lastly it is the Prime Minister's decision.

Interview, 8.11.89.

Telecommunication Commission.[159] In the 1980s ASTEC organised or participated in several large-scale conferences or workshops aimed at encouraging the scientific community to participate in formulating policy recommendations to government, and at engendering a sense of commitment within the science system.[160]

ASTEC has been criticised for representing the conservative organisations in the science system and therefore being out of touch with small, innovative science organisations. Professor Ian Lowe, for many years a member of the National Energy Research and Development Demonstration Council (NERDDC) said of ASTEC in 1989:

> Generally ASTEC has represented an older generation of good scientists and engineers from industry. It's been a consistent criticism of ASTEC from many people over the years that, apart from the late Leon Peres who was on it for a short time, it has never had anyone on it who knows anything about science policy, setting up priorities in science, the politics of science or the organisation of science. It consists largely of scientists who have prospered under the present system. Generally they see scientific advice as being more of the past recipe.[161]

This assertion, however, is not borne out by an examination of the members in the years 1977, 1986 and 1990. Table 4.1 illustrates the membership of ASTEC by sector and discipline and reveals that at least one member of ASTEC through this period has had considerable experience of science and technology policy.[162]

If there is a trend it would seem to be that expertise in the management and financing aspects of the commercialisation of research is gaining prominence of membership. However, the capacity to control membership (for example, the exclusion of CSIRO) and the use by consecutive governments of ASTEC as a means of formulating and ensuring commitment to policy in the science system, means that ASTEC could be seen as a corporatist development in the science policy community. However, as mentioned above in discussing the networks of the international attentive public, the type of policy interaction exhibited in ASTEC does not quite fit any of Coleman and Skogstad's policy network categories, in this case because of the lack of a corporatist implementation function for ASTEC. However, its influence and role over fifteen years cannot be categorised as pressure pluralism or clientele pluralism because it is a state-established agency. Perhaps *quasi-corporatist* is the most appropriate term to describe the ASTEC relationship with the executive core.

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159 Ibid., p. 39.

160 For example:
1981 with UNESCO, the National Objectives and Priorities Workshop;
1983 with the Department of Science, the National Technology Strategy;
1989 with the Centre for Technological and Social Change, Profile of Australian Science.

161 Associate Professor Ian Lowe, Griffith University, *Interview,* 1.11.89.

162 Searches of Australian business directories revealed no trace of 'BWD Industries'.
Brett & Co. is a supplier of building requirements. Lloyd Zampatti is a director and member of ASTEC.

Table 4.1: The composition of ASTEC 1977-1990

	Union & Other	*Higher Education*	*Industry*
1977	Victorian Trades Hall Council	organic chemistry electrical engineering political science vice chancellor ex-vice chancellor	pastoral radio & telecommunications mining medical research institute chemical mining & steel paper manufacturing
1986	Federated Clerk's Union	biological science physical science economics science & technology policy political science medicine mechanical engineering electrical engineering	rural producer supplier monoclonal manufacture BWD Industries mining computers Brett & Co
1990	Federated Clerks' Union	chemistry economics jurisprudence physical geography physical sciences & engineering medicine vice chancellor science & technology policy private university representative	management steel grazier computer manufacturer Brett & Co

Data source: ASTEC *Annual Reports,* 1977, 1986, 1990.

The period from 1965 to 1989 in science policy saw the gradual, if lumpy, development of an overarching set of decision-making relationships in the science policy community. These have changed from the conservative clientele pluralist networks of the Menzies and Holt governments to the more corporatist techno-economistic networks of the Hawke governments. The lumpiness of the transition was in many ways due to the continuing perception of the core executive that research was not central to the nation's economic wellbeing. Both Whitlam and Fraser toyed with the concept but either lost interest or deferred to the organised interests of subgovernments. The messianic techno-economistic zeal of Barry Jones furthered the development of a superstructural subgovernment, but it was not until Hawke himself became personally involved in the issues in 1989 that fundamentally new structures were established.

7. The 1989 May Statement on Science and Technology: A Watershed in Science Policy-making in Australia

The intense process of change in the science policy community in the 1980s created foci of discontent among the organised interests in all sectors of the policy community. The discontent was highest in areas where scientists perceived incongruence between subgovernment rhetoric about the benefits that science could bring to Australia and the realities of increasing subgovernment control over their research agencies, resource allocations and the organisation of research. The economic rationalism of the core executive and the techno-economism of the science policy subgovernment merged, for the scientists, into a political and bureaucratic ideology which threatened the autonomy of the 'scientific estate'.

Against this background of increasing conflict Science Minister Jones took a proposal on research funding to Cabinet in October 1988. Cabinet's response was to form an Inter-Departmental Committee to examine support for science and technology in Australia.[163] In the same month the Prime Minister opened the National Science and Technology Centre in Canberra and was met by a thousand scientists waving placards with such slogans as 'Sow science and reap prosperity'; 'Foster science not sport'; and 'Would the last scientist in Australia turn off the bunsen burner!'. From this time Hawke took a personal interest in science policy.[164]

In November 1988 CSIRO and the Commission for the Future held workshops on the Greenhouse Effect. This publicity about the way in which science can be important in informing public debate on contentious issues was seen by government as a positive aspect of science which could be electorally useful. Also in November the Inter Departmental Committee on Science and Technology reported to the Structural Adjustment Committee of Cabinet. This period was one of decision about which departments should participate in the core processes of science policy.[165] The Committee used information being compiled by various agencies including:

IDC:	• Draft Science and Technology Statement;
Jones:	• Oustanding Issues in Science and Technology Capacity;
DEET:	• Review of Higher Education Research Policy & Postgraduate Awards;
	• responses to the Mackinnon Report on Marine Science & Technology;
DPIE:	• Research Innovation and Competitiveness Report;
DCSH:	• new policy proposals for public health and medical research;
ASTEC:	• Core Capacity of Australian Science;
	• Profile of Australian Science.

A Science and Technology Statement Cabinet Sub-Committee consisting of the concerned Ministers was set up to negotiate the final contents of the Statement. Keir reports that this was an 'important and interesting' process because of the variation in demands by the different Departments. DITAC, DEET and the Minister for Science were asking for quite large amounts of money but DPIE was suggesting greater co-ordination and management of existing resources and asked for only $1.3m extra. The demands proliferated the process of negotiation according to Hendrickson's

163 Marie Keir, (Consultant to the Minister for Primary Industry and Energy on Research and Development Policy), 'The emergence of science policy on the agenda', Science and Society, ANU Public Affairs Conference, Canberra, 7-9 June 1989.

164 Ibid..

165 Ibid., Keir reports that at first only five departments (Prime Minister & Cabinet; Industry, Technology & Commerce; Primary Industry & Energy; Education, Employment & Training; Community Services & Health; were involved with Defence 'coming in and out'. Later Arts, Sport, Environment, Tourism & Territories; and Finance joined the Committee.

Law.[166] The process of deciding the wording and substance of the Statement involved many meetings of Ministers and ministerial staff. Keir's impression is that those who actually wrote the Report (officers of the Innovation Branch of DITAC) were: '...the ones who had their points of view most strongly represented'.[167]

A major factor in keeping the issue alive for the government was the continual and unprecedented barrage of television and radio interviews about science policy, press articles, press releases, personal visits, faxes and letters to ministers (although special pleading for individual projects was declared by Ministers at this time not to be an effective form of lobbying because they wanted to dispel the impression that priority decisions were made by politicians rather than by scientists).[168] Typical of these was the article in the *Weekend Australian* by science writer Julian Cribb, entitled 'A dark age dawns in Australia'. This article gave details of scientists who had left Australia and the results of the ASA/ANU poll showing that sixty per cent of young Australian scientists were prepared either to leave Australia or science because their future was too uncertain.[169] In the same issue of the *Weekend Australian* was a three-page feature article on CSIRO achievements. Much of the material was generated by scientists who presented the issues for the public in simple terms such as the dollar value to the Australian public of completed and potential research projects from individual laboratories. By the end of November 1988 Laurie Hammond, Vice-President of FASTS, wrote in an *Age* editorial that 'science's phantom army' had won the battle for recognition to such an extent that Prime Minister Hawke, with his keen sense of electoral salience, had personally taken up the colours for the scientific community.[170]

The formation of an Inter Departmental Committee was hailed as a breakthrough in the co-ordination of science policy in Australia. This ad hoc structural response to discontent throughout the science policy community was made permanent in 1990. Other measures announced in the May 1989 Science and Technology statement, such as the announcement of a Chief Scientist to advise the Prime Minister, further cemented the existence of a superstructural subgovernment for the science policy community.

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166 Ibid., 'If a problem causes many meetings the meetings become more important than the problem'.

167 Rymer, Interview, 30. 4. 90.

168 Keir, 'The emergence of science policy on the agenda'.

169 Julian Cribb, 'A Dark Age Dawns in Australia', *Weekend Australian,* October 1-2, 1988, p. 25.

170 Laurie Hammond, 'A win for science's phantom army', *Age,* 26 November 1988, p. 11.

8. The Superstructural Subgovernment

8.1 A new Minister for Science and Technology

In the 1990 election campaign Hawke and his ALP advisers used the issue of the production and use of scientific knowledge in Australia as a major component of the speech launching the campaign. It was therefore something of a shock to the scientific community when Barry Jones was relegated to the backbenches and newcomer Simon Crean was made Minister for Science and Technology in his place. Several explanations were put forth. One suggested that the reply Jones had made to a question on notice, which had revealed extensive cuts in funding for certain environmental CSIRO programs, had severely embarrassed Hawke at a time when he was trying to woo the votes of both the environmentalists and the scientific community.[171] Another is that his abrasive negotiating style and reluctance to accept short-term compromises within the political system lost crucial votes in Caucus.[172]

The appointment of former ACTU President, Simon Crean, to the position of Minister for Science and Technology was seen in the science policy community as an indication of the increasing seriousness with which science policy is seen in the executive core.[173] Crean tried to assert some autonomy into the position. With the support of both the Chief Executive and the Chair of CSIRO, he insisted that ministerial requests for research to be undertaken by CSIRO should be scrutinised by him personally.[174] He also blocked the appointment of a senior DITAC official to the Office of the Chief Scientist against the wishes of the Chief Scientist and the Secretary of the Department of the Prime Minister in which the Office is located. The interference is reported to have caused 'much bitterness and resentment' in the upper levels of the DITAC bureaucracy.[175]

8.2 The Co-ordination Committee on Science and Technology

The establishment of the Co-ordination Committee on Science and Technology (CCST) was announced in the May Statement. The Committee: '...facilitates the sharing of information and assists the co-ordination of programs and policies concerned with science and technology.'[176] It was established to enhance the coherence of the allocation of government resources to scientific activity by creating a

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171 'Jones reveals woeful state of CSIRO R&D', *Scitech,* vol. 9, no. 9, September 1989, p. 11.

172 'Sadness at Jones' Demise', *Scitech,* vol.10, no. 4, April 1990, p. 1.

173 "S&T Gains High Profile At Last', Ibid..

174 'Crean Vets Requests', *Scitech,* vol.10, no. 8, August 1990, p. 10.

175 'Ministerial Action Rocks Bureaucracy', *Scitech,* vol.10, no. 9, Septmenber 1990, p. 3. Dr. Bell, formerly Head of the Policy and Projects Division, and having had four years as Director of Science and Technology Policy for the OECD, was displaced by the abolition of the Division and appointed to the Building and Services Industries Division. After the Crean blocking, and under a new Minister for Science and Technology, Ross Free and a new Secretary for DITAC, he was later re-instated at the top level of science policy-making as one of the two Deputy Secretaries; also holding the position of Chief Science Advisor for DITAC. In 1993 he was appointed the Secretary of DITAC.

176 Ibid., p. 10.

forum in which officials from the most important science portfolios could inform colleagues in other departments of their activities.[177]

The Council is expected to redress some of the grievances of Ministers outside DITAC who, for example, find that their influence on such issues as research priorities in CSIRO are being blocked by the DITAC Minister and the Minister Assisting the Prime Minister on Science and Technology. One such Minister is the Minister for Primary Industries and Energy whose portfolio parallels the operations of four of the six CSIRO Institutes, but who, in opening a conference entitled 'Crisis in Science', revealed that he had little input into policy for CSIRO.[178]

8.3 The Prime Minister's Science Council

The creation of the Prime Minister's Science Council provides a forum outside normal departmental channels for the Prime Minister, other Ministers, members of the scientific community and representatives of industry to 'consider' issues concerning science and technology.[179] The membership of the Science Council can be considered as the heart of the core of the subgovernment of science policy in Australia. In 1989 the original membership was:

Minister Assisting the Prime Minister on Science and Technology;
Minister for Employment, Education and Training;
Minister for Primary Industries and Energy;
Minister for Community Services and Health;
Chief Scientist;
Chair of ASTEC;
Chief Executive of CSIRO;
Director of the Walter and Eliza Hall Institute;
Managing Director of Computer Power;
Managing Director of CRA;
Managing Director of Wesfarmers;
Managing Director of TNT;
Managing Director of AMRAD
Head of Department of Systems Engineering, ANU;
Professor of Pure Mathematics, University of Western Australia.[180]

In 1991 to the above were added:

Minister for Industry, Technology and Commerce;
Minister for the Arts, Sport, the Environment, Tourism and Territory;
Chair of Memtec Ltd.;
President of the Academy of Science;

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[177] In the first year of its existence the Committee considered such issues as:

- human resources for R&D and the related question of career structures for scientists and engineers;
- ways of setting directions for Australian research;
- action following the Government's statement on the environment
- the Committee's role in the provision of advice to the Government on major research projects and facilities.

Ibid..

[178] 'Ministers want more say in CSIRO', *Scitech,* vol. 9, no. 6, June 1989, p. 10.

[179] Australia, Science and Technology for Australia, p. 20.

[180] Prime Minister's Science Council, *Resources for Science and Technology and their Utilisation,* Commonwealth of Australia, 1989(no page number).

President of the Academy of Technological Sciences and Engineering;
President of the Australian Vice-Chancellors Committee;
Assistant Secretary, Federated Clerks' Union.[181]

The Council meets twice a year to discuss an agenda set primarily by the Chief Scientist, and to listen to papers prepared by independent working groups. Significantly the Department of Defence and the DSTO are not included. The 1991 membership shows a widening to include the higher education system and the Academies of the scientific community. In 1965 it would have been unthinkable that these agencies were not included in the first round of membership. Their original omission and the inclusion instead of industrial scientists and managers is a dramatic instance of the ideological shift in science policy from conservatism to techno-economism, and a concommittant change in type of superstructural subgovernment policy network from clientele pluralist to corporatist.

8.4. The Chief Scientist

In 1989 the policy role of ASTEC was supplemented by the establishment of the office of Chief Scientist. The first incumbent is Professor Ralph Slatyer who was for several years a member, and then Chair, of ASTEC. Slatyer affirms the advantages of being close to the Prime Minister and Cabinet:

> You see, ASTEC is seen to be independent of government, in other words free to criticise government whenever they want to. That's what I used to call when I was Chair of ASTEC, an 'outsider role'. It has its benefits in that you can say whatever you want to say. That's the up side. The down side is that you're not an insider. We used to try and play an insider role as well at ASTEC, that's providing briefing to the PM on Cabinet submissions and things like that, but it's just not the same. I hadn't realised quite the difference as being inside the department. So all the formal advice that goes to the PM which might be on migration or economic policy or anything, this department has an overview role across all arms of government. My advice is incorporated in the flow of information which goes to the PM. There's a whole structure that takes care of that. He's got an office staff at Parliament House which is aimed at just getting all that stuff in front of him in an orderly and balanced way, so to be part of that is extremely valuable. I hadn't realised the difference that that would make.[182]

The Chief Scientist personally advises the Prime Minister on science and technology affairs, chairs the Prime Minister's Science Council, the interdepartmental Co-ordination Committee on Science and Technology and the Cooperative Research Centres Committee. His Office also administers the Cooperative Research Centres Program. Under this program, which is a personal initiative of the first Chief Scientist (though the idea was first proposed in the Vernon Report of 1965[183]), 50 new

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181 The Managing Director of TNT was replaced by the Chairman of Memtec. The Managing Director of AMRAD in 1989 was Dr John Stocker, the Chief Executive of CSIRO in 1990. *Scitech Technology Directory 1992 Edition*, p. 84.

182 Personal Communication, Professor Ralph Slatyer, 30.4.90

183 Australia, Committee of Economic Enquiry, *Report 1965*, p. 424.

research centres will be established jointly by universities, public research organisation and private industry, between 1990 and1995 at an eventual cost of $100m a year.

Through control over the structures, orientation and resources committed to these centres the Chief Scientist therefore has considerable power in the science policy community. Through the chairs of the Science Council and the Co-ordination Committee the Chief Scientist can present agendas for consideration by the Prime Minister, other Ministers and top public servants. The office is a nexus between the political system and the science system and is responsible to Parliament only through the Prime Minister and Cabinet. The advice given is therefore independent of Ministers in whose portfolios lie responsibility for government science agencies and programs involving the funding of scientific activity outside the public sector. This position gives the Chief Scientist considerable personal influence in the formulation of science policy.[184]

9. The Sectoral Subgovernments

The science policy subgovernments are now formally linked through the Prime Minister's Science Council and the CCST. DPIE is the only department to have an in-house research council to co-ordinate scientific activity, but DITAC and DASETT both have Chief Science Advisers and DEET has the ARC to provide intra-departmental advice on research activity and scientific issues. CSIRO plays a much-reduced role in science policy formulation. The location of the Organisation under the auspices of DITAC rather than DPIE or DASETT symbolises the intention of the government to emphasise the relationship between CSIRO and manufacturing industry. The extent to which this rhetoric has become policy reality was demonstrated recently when it was reported that signficant bureaucratic actors in the sectoral subgovernments had decided that CSIRO was to be excluded from membership of the new rural research committee which will replace the standing committees on agriculture, soil and water resources. The Minister for Primary Industries had to intervene to ensure the representation of CSIRO.[185]

DPIE has, through a series of structural innovations, consolidated its control over rural research. Through the establishment of the Primary Industries and Energy Research Council, the Rural Industry Research Corporation, and the proposed

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184 The Keating government changed the name of the Prime Minister's Science Council to Prime Minister's Science and *Engineering* Council to reflect the applied nature of the role of the scientific community in Australia in the 1990s.
In 1993 the 'administration' of ASTEC was merged with that of the Chief Scientist in the Department of Prime Minister and Cabinet after protracted discussion about the future of the agency.
Peter Pockley, 'ASTEC partially merged with PMSEC', *Search,* vol. 24, no. 7, August 1993, p. 195.

185 'Crean may dump CSIRO in rural policy', *Australian,* 10 November 1992, p. 5.
'Crean backs CSIRO in policy debate', *Australian,* 11 November 1992, p. 2.

standing committee, the Department has the capacity to exercise control through a co-ordinative matrix not yet achieved by other science policy subgovernments.

The main portfolio responsibility for science policy lies with DITAC.[186] The Science and Technology Strategy Section is responsible for the reactive process of writing speeches, answering ministerial correspondence and preparing answers to parliamentary questions. The Branch briefs Ministers before meetings of the Prime Minister's Science Council, presents issues to the Co-ordination Committee on Science and Technology and interacts with the Committee on Science and Technology Policy of the OECD. The Science and Technology Resources Analysis Section produces the Budget Paper on Science and Technology and the data for the ongoing Science and Technology Indicators program. The Science and Technology Awareness Section, which was established after the 1989 May Statement runs programs designed to increase the broad science and technology awareness of the general public.[187]

The subgovernmental actors in DITAC see the science policy community in Australia as consisting of 'funders, users and performers' of scientific research. The Department's science policy functions are embedded in a wider mission of '...the support of sustainable international competitiveness throughout the manufacturing and service sectors'.[188] Science and technology policy form only a small part of the Departmental activity and show signs of isolation from other subgovernment agencies. The impression gained is that the policy section of DITAC does not foster outreach interaction. For example, when asked about contact with the two main industrial lobby groups, the AIRG and the Institution of Engineers, the Director of the Science and Technology Strategy Section of DITAC conceded that there was none and that there 'should be more'.[189] Marshall reports that, until 1990, there was a deliberate DITAC policy of maintaining distance from client groups in order to avoid too-close identification of officers with the interests of industry groups. He cites the lack of interaction between the IR&D Board and the ARC; the absence of liasion between senior DITAC officials and CSIRO staff; and the avoidance of co-ordination between DITAC and DPIE on science policy issues as evidence.[190]

This may be a harsh judgement. The Joint Committee on Public Accounts in its recent comprehensive Inquiry into Public Sector Research and Development did not

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[186] In 1990 the Department consisted of seven divisions, the Patents Office, the Bureau of Industry Economics and the Commission for the Future. The Innovation Division administers the portfolio's granting and advisory programs for science policy. Within the Division is the Science and Technology Policy Branch which supplies information and analysis for science policy agencies inside and outside the portfolio.

[187] Rymer, Interview, 30.4. 90.

[188] Australia, Joint Committee of Public Accounts, *Inquiry into Public Sector Research and Development,* AGPS,Canberra, 1992, Submissions and Incorporated Documents, vol. 5, pp. S644-S645.

[189] Rymer, Interview, 30.4. 90.

[190] Neil Marshall, 'Pressure Groups, Bureaucratic Pluralism, and the Fragmentation of Australian Science and Technology Policy', *Australian Journal of Public Administration,* vol. 50, no. 2, June 1991, pp. 154-169, p. 160.

censure DITAC for bureaucratic ineptitude.[191] The Committee did see a need for more interaction between DITAC and DPIE as the two largest research-oriented departments, particularly in the area of information collection and dissemination. However, the interpretation by Marshall of bureaucratic territorialism over agencies and ideas certainly fits Pross's notions of subgovernmental defence of policy activity.

10. Conclusion

Since 1965 there has been a general transition in the science policy community of Australia from weakly associated clientele pluralist networks of organisational and individual interests to the situation in 1990 of corporatist networks participating in advisory and allocatory agencies designed partly by the core executive and partly by the superstructural subgovernment. Table 4:2 summarises these changes.

Table 4.2: Changes in science policy networks 1965-1990

	1965	1990
superstructural subgovernment	clientele pluralist	corporatist
Higher education	clientele pluralist	concertation
CSIRO	concertation	corporatist
Manufacturing	pressure pluralist	clientele pluralist
Rural	corporatist	corporatist

The overall pattern is one of increasing core executive control over the organisation of the science policy process. In order to protect their autonomy from what they perceive as further erosion, scientists have organised pressure groups within the attentive public which seek to influence the allocation of public resources to the production of scientific knowledge and to retain control over research agencies. Political actors have come to appreciate the importance of scientific knowledge not only in solving problems in rural economic production and providing an image of Australia as a civilised nation, but also to the position of Australia in the global economic community. Significant actors from the pressure groups are co-opted by subgovernments into policy formulation and implementation. Underlying the significant changes in the organisation of the science policy process is the continuing power play between actors supporting ideologies with conflicting ideas about the objectives and organisation of research. It is no longer sufficient for governments simply to hand out resources for scientists to maintain their research organisations and their international reputations. Corporatist research agencies and superstructural

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191 Of 102 submissions to the Committee 37 per cent were from private sector users of public sector research funding. Nineteen per cent of these expressed negative opinions about the system of funding and the majority of these were ideological objections to the concept of government intervention in the marketplace. Only two users of DITAC innovation grants had negative experiences of the process. Joint Committee of Public Accounts, *Inquiry into Public Sector Research and Development,* Submissions and Incorporated Documents, vols. 1-10.

councils have been created to widen both political and scientific perspectives. Decisions have to be made about co-ordinating and prioritising objectives and outcomes in the increasingly complex and costly process of the production of scientific knowledge. The next four chapters analyse the way in which this has been achieved. beginning in the following chapter with an account of changes in the allocation of public resources to the production of scientific knowledge in Australia.

CHAPTER 5

THE RATIONALISATION OF RESOURCE ALLOCATION

> ...the outputs of the policy-making process can be said to reflect the relative strengths of those involved, so that stability in a power structure will result in a certain stability of policy....If the policy output appears to have a coherence and substantive content that might justify the description 'rational', then this reflects the ability of a particular group to dominate proceedings.[1]

In any policy arena the outputs of the policy-making process derive from a complex interaction of the political system, the organisational systems of administration and performance, the exercise of power through the capacity of certain actors to change rules, ideas and resources to further their interests and ideologies, and the environment in which policy action occurs. These outputs can be used to measure different patterns of influence. The allocation of public financial resources to a policy community is by far the most cogent indicator of political commitment to policy and of interest group power. Financial resources can be considered as intermediate outcomes because they are both the end of one set of policy decisions and the means to the achievement of other policy outcomes.[2] There are therefore three issues to be considered in the analysis of the distribution of financial resources: who controls the processes of allocation; who receives the resources; and under what conditions of use?

1. CHANGES IN THE GENERAL PATTERN OF FUNDING

One of the most significant elements in the transition in science policy between 1965 and 1990 has been the way in which the allocation of resources for the production of scientific knowledge has changed both in the pattern of resource distribution and in the mode of decision-making about how resources should be allocated. The change has been from a pattern of resource allocation based on objectives of national and cultural importance, such as defence and radio astronomy research, to one based on techno-economistic assumptions by governments that scientific knowledge is part of economic production. Control over decisions about the allocation of funds has passed from elite scientists to specialised, broadly-based, subgovernmental agencies. This chapter focuses on the changing patterns of resource allocation by examining the budgets of significant science agencies and the mechanisms of resource allocation in several sectors of the science system. This is done by comparing not only the two 'snapshot' years, but also the intervening period. Wherever possible the amounts have been converted to 1990 values.[3]

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1 Freedman, quoted in W.I. Jenkins, *Policy Analysis: A Political and Organisational Perspective*, p. 35.

2 Jenkins, *Policy Analysis: A Political and Organisational Perspective*, p. 225.

3 ABS government expenditure implicit price deflators were used to calculate the deflators for each year since 1965.

1.1 Funding proportions in the budget: 1965 and 1990

Portfolio funding can be used as an indicator of the perceived importance of scientific knowledge to governments. The composition of portfolios changes quite considerably through time but examination of the agencies within the portfolio, and analysis of the funds allocated to each, can show where the functional priorities of different governments lie.[4]

1.1.a Research and development resource allocation by portfolio

Figures 5.1 and 5.2 show the distribution of financial resources allocated to research and development through Appropriation Acts 1 and 2 in the 1965-66, and 1990-91 Budgets.[5,6] The estimated total of these appropriations in 1965 is $110m ($909m in 1990 dollars). The largest portion is allocated to the Department of Defence and 68 per cent of this allocation of $41m was spent on the Weapons Research Establishment. The next largest portion of 26 per cent of total funds was allocated to the Department of National Development. Funding for science in the Department is increased by the presence of two large agencies. The Bureau of Mineral Resources accounted for $14m of the Department's $31m for research and development and $10m of the Bureau's budget was spent on oil exploration. Funds for the Australian Atomic Energy Commission, which was a statutory authority, account for another $8m. CSIRO received 24 per cent of the government's total budget outlays on research and

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ABS, *Australian National Accounts Historical Estimates,* Cat. no. 5206, 1982, pp. 18-21; *Australian National Accounts,* Cat. no. 5207, March Quarter, 1990, p. 61.

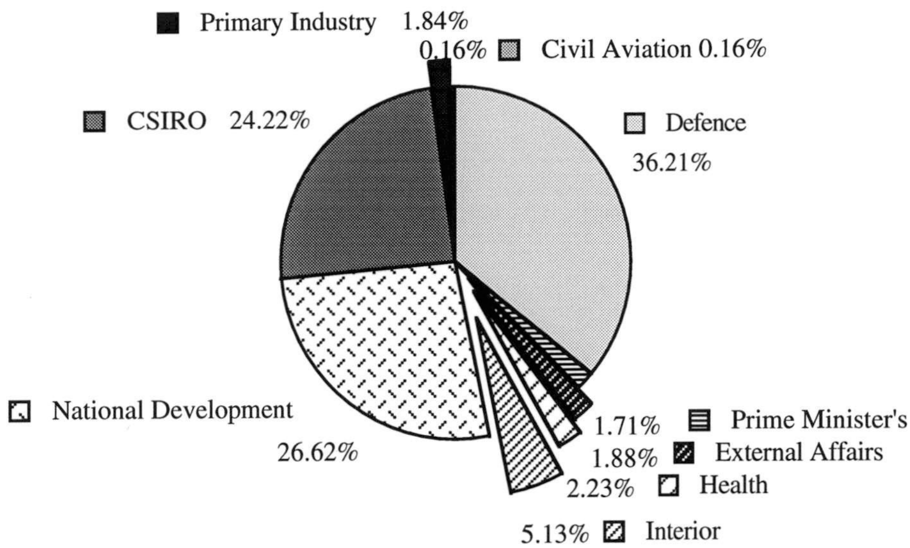
4 The fragmented nature of resource allocation to the science policy community means that the data used in this chapter have been compiled from a variety of sources. In 1965 the reporting of public sector finances was fairly simple and usually consisted only of the annual accounting procedures of the Budget processes. In 1990 the process is much more complex and, in some ways, equally as impenetrable. The longitudinal sets of data represented here cannot therefore be taken as absolute. The data for this section was taken from the following sources.
Australia. Budget 1965
Advance to Treasurer - Statement of Expenditure, Parl. Paper 314, 1964-66, vol. V.
Auditor-General's Report & Treasurer's Statements of Receipts and Expenditure, Parl. Paper 312, 1964-66, vol. VI.
Commonwealth Payments to or for the States, Parl. Paper 185, 1964-66, vol. VII.
Estimates of Receipts and Summary of Estimated Expenditure, Parl. Paper 184, 1964-66, vol. VII.
Supplementary Report by Auditor-General, Parl Paper 359, 1964-66, vol. VI.
Australia. Budget 1990
Budget Paper no. 1, Budget Statements, 1990-91, Parl. Paper 115, Canberra, 1990.
Budget Paper no. 2, Commonwealth Public Account, 1990-91, Parl. Paper 116, Canberra, 1990.
Budget Paper no. 3, Portfolio Program Estimates 1990-91, Parl. Paper 117, Canberra, 1990.
Budget Paper no. 4, Commonwealth Relations with Other Levels of Government, 1990-91, Parl. Paper 118, Canberra, 1990.

5 A spreadsheet of all research and development monies and the agencies to which they were allocated was compiled from the Parliamentary Papers documenting the three Appropriation Bills for the issue of monies from the Consolidated Revenue Fund. In 1965-1966 some funds were given in pounds; other were in dollars. All amounts used in the analysis have been converted to dollars using a 2:1, dollar to pound ratio.

6 Since 1989 there has been a separate Budget Paper for Science and Technology funding; however, in order to analyse the appropriations in the same detail as the 1965 appropriations, appropriations from the four major Budget Papers for 1990-91 have been computed. The data set includes Appropriations Acts 1 and 2.

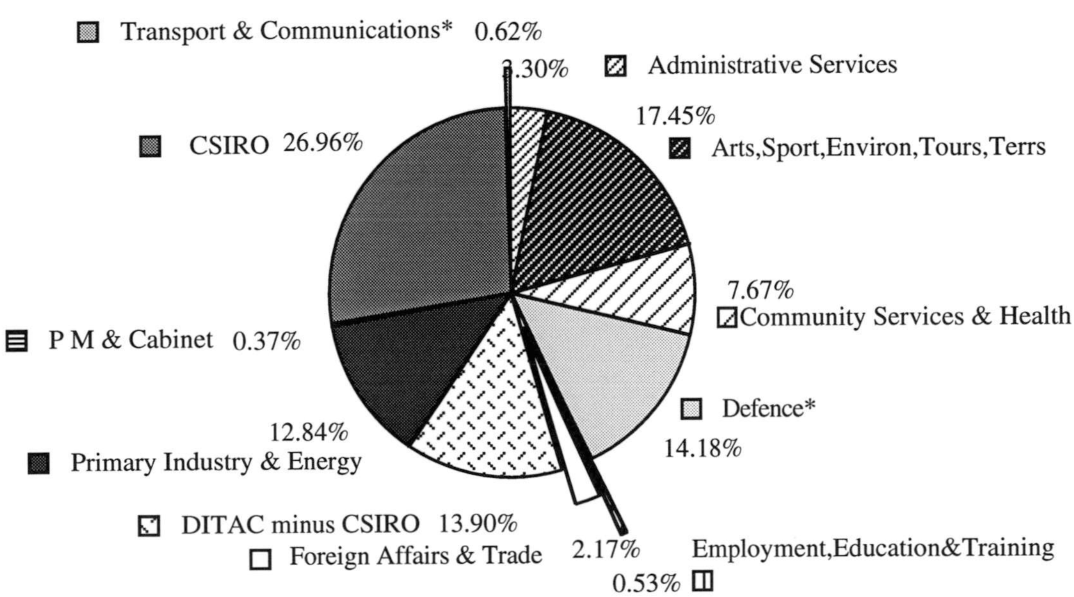
development (a more detailed analysis of the changes in CSIRO's budget is given in section 2.2 below).

Figure 5.1: Australia, research and development, Appropriations Acts 1 & 2, 1965-66



Data source: *Parliamentary Papers,* 1964-65-66, vol. V, pp. 517-819; vol. VI, pp. 853-855.

Figure 5.2: Australia, funds for research and development, Appropriations Acts 1 & 2, 1990-91



Data source: *Budget Paper No. 2: The Commonwealth Public Account,* 1990-91, pp. 40-50.[7]

7 Figure 5.2 illustrates appropriations from Appropriation Acts 1 and 2 for 1990-91 in order to make the comparison with the situation in 1965 and to emphasize the increase in certain appropriations for science and technology. The figures for the Department of Defence in Appropriations Acts 1 and 2 for 1990-91 indicate a total sum of $7.7m for science in the portfolio and this would have given a misleading comparison with 1965, so the total allocation

The allocation of resources to the production and use of scientific knowledge in the Department of Primary Industry appears low considering the importance of primary industry in economic production in Australia in 1965. However, the Department was then responsible only for minor agricultural research agencies and extension services. Research and development for Australia's mining, petroleum, timber and fishing industries were not part of the portfolio. Most research for rural production was undertaken by CSIRO where nearly 70 per cent of the budget was devoted to rural research.

The remaining Departments had minor research budgets. The Antarctic Division formed part of the Department of External Affairs. The Department of the Interior was responsible for the Bureau of Meteorology and the Ionospheric Prediction Service. The allocation for the Department of Health shown here includes $0.8m for the Medical Research Endowment Fund and $1.4m for the salaries and allowances of medical and scientific officers which cannot be separated. In 1965 responsibility for education at the federal level consisted of the Commonwealth Office of Education located in the Prime Minister's Department. Therefore there is an allocation for research and development to that department of nearly $2m. The items listed include grants to the Australian Academy of Science; the Commonwealth Postgraduate Awards and $94,000 for the purchase of laboratories and equipment for independent schools in the ACT and the Northern Territory.[8]

An estimate of the total allocation in 1990 using the same calculations as for 1965 is $1492m: a 50 per cent increase in real terms. In 1990 the picture of the allocation of resources had changed quite markedly to one in which more departments have more equal shares of the research and development allocation. Most noticeable is the drop in defence research from 36 per cent to 14 per cent of appropriations.[9] The total DITAC appropriation including CSIRO is now over 40 per cent of the total research and development budget; however, this includes the 52 per cent of CSIRO's budget in 1990 which is for rural research (see section 2.2 below).

The Department of Arts, Sports, the Environment, Tourism and Territories (DASETT) is responsible for many science-based agencies and the research and development appropriation comprises 17 per cent of the allocation to science in Appropriation Acts 1 and 2. The Bureau of Meteorology accounts for nearly $128m

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for defence science given in Budget Paper 3 is included instead. Similarly, there was no appropriation for science for the Transport and Communications portfolio in Appropriations 1 and 2 for 1990-91 but a figure of $9.3m was given in Budget Paper 3 and this also was included to complete the science resource allocation picture for 1990.

8 Ibid., p. 581.

9 Unlike CSIRO, ANSTO, AIMS and other Commonwealth Government science organisations, the Defence Science and Technology Organisation is not mentioned in Appropriation Acts 1 and 2. Amounts of $211.2m; $215m and $213m are given respectively in *Science and Technology Budget Statement 1990-91*, p. 31; Budget Paper no. 3 1990-91, and *Defence Report 1990-91*, AGPS, Canberra, 1991, p. 123.

of the Department's $262m research budget. Other sizeable agencies within the Department are the Antarctic Division with $63m of research funds; the Office of the Supervising Scientist and Alligator Rivers Research Institute with an allocation of $6.6m a year[10] and the Tasmanian World Heritage Area which accounts for nearly $6m a year.

The proportion of resources allocated to the Department of Primary Industry and Energy has increased sixfold in real terms since 1965. The portfolio now has responsibility for overseeing the development of mineral and energy resources and within its juridiction are included such agencies as the Bureau of Mineral Resources and the Australian Bureau of Agricultural and Resource Economics. In Appropriations Acts 1 and 2, DEET is allocated $7.2m; however, the Australian Research Council funds, which are part of Special Appropriations, boost the allocation by $175m.

The share of the science budget allocated to the Department of Prime Minister and Cabinet has fallen from 1.7 per cent to 0.4 per cent. This proportion will rise considerably from 1991-92 as the Co-operative Research Centres program reaches its target allocation of up to $165m by 1995. Responsibility for the Centres will then be given to: ' ...the appropriate operating area of government'[11] The Department of Community Services and Health research budget rose from 2 per cent in 1965 to 8 per cent in 1990. The allocation to the Department of Foreign Affairs and Trade includes $17m for the Australian Centre for International Agricultural Research; $11.5m for international research and development organisations, and $3.2m for the International Atomic Energy Authority. This appropriation is not mentioned in the Science and Technology Budget Statement. The Department of Administrative Services in 1990 is responsible for three scientific agencies, two of which operate from Trust Acounts. The two are the Australian government Analytical Laboratories (AGAL) and the Australian Survey and Land Information Group (AUSLIG). The Ionospheric Prediction Service is funded totally from the departmental budget.[12]

1.1.b Other appropriations 1965 and 1990

Some appropriations for research are by Special Purpose Acts of Parliament which obtain monies from the Consolidated Revenue Fund and the Loan Fund; and by

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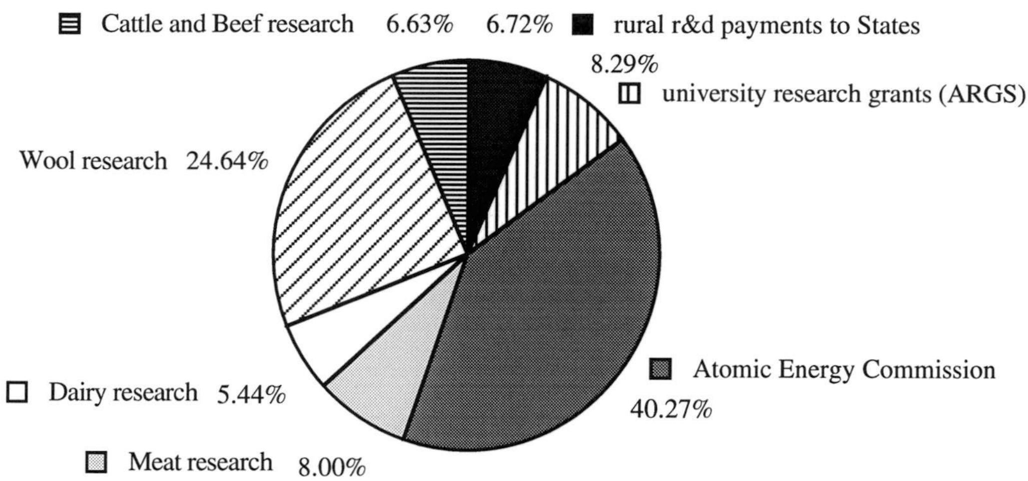
10 The Office of the Supervising Scientist was established in 1978 under the Environment Protection (Alligator Rivers Region) Act 1978 to monitor the effect of uranium mining on the region. Department of the Arts, Sports, the Environment, Tourism and Territories, *Annual Report 1990-91,* AGPS, Canberra, 1991, p. 157.

11 Australia, *Budget Paper no. 1: Budget Statements 1990-91,* AGPS, Canberra, p. 3.322.

12 There is a reporting inconsistency in that the AGAL ($16.5m) and the Ionospheric Prediction Service ($2.4m) are mentioned in the Science and Technology Budget Paper but AUSLIG ($33m in Appropriations Acts 1 & 2) is not.

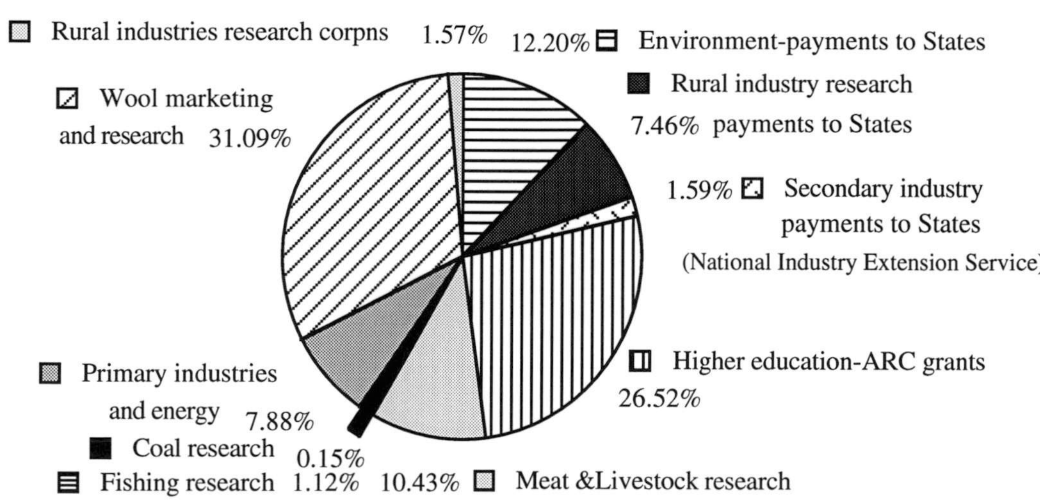
Specific Purpose payments.[13] These appropriations are illustrated in figures 5.3 and 5.4.

Figure 5.3: Australia, funds allocated to research and development, other appropriations 1965-66



Data source: *Parliamentary Papers,* 1964-65-66, vol.. VI, pp. 853-855;
vol.. VII, pp. 493-499;
vol.. VII, pp. 705-709;
vol.. VII, p. 719.

Figure 5.4: Australia; funds allocated to research and development, other appropriations, 1990-91



Data source: *Budget Paper No. 2: The Commonwealth Public Account,* 1990-91, pp. 40-50.
Budget Paper No. 4: Commonwealth Financial Relations with Other Levels of Government, 1990-91, Table 9, pp. 196-201.

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13 Australia, *Budget Paper no. 2, The Commonwealth Public Account 1990-91,* AGPS, Canberra, p. 1.
Specific Purpose payments began during the Depression as a means of Commonwealth Government support for emergency relief measures. The use of such grants proliferated in the 1940s when the Commonwealth Government formally took over some of the States' financial responsibilities in the areas of health and welfare; and again in the 1970s when the Whitlam Governments used such payments to finance certain policy initiatives in areas of States' responsibility.

In the 1965-66 Budget $25m ($216m in 1990$) was allocated to research and development and associated activities through Specific Purpose grants, Special Appropriations and other appropriations. $3.6m was through Specific Purpose grants for research and development under thirteen areas of State government activity including university funding, natural diaster relief, long service leave for coal miners and blood transfusion services. Six of the areas are related to research and development.[14] They are:

Research grants	55%
Dairy Industry Extension Service	19%
Agricultural Advisory Service	15%
Minor agricultural research	0.7%
Tobacco Industry Extension Service	1.4%
Cattle Tick control and research	10%

This amount is 3 per cent of the appropriations for research and development from Appropriations Acts 1 and 2. The major beneficiaries were rural industry researchers (44 per cent) and academic researchers (55 per cent).

The research grants appropriated here are the first funds for the newly-established Australian Research Grants Scheme (ARGS) announced by Menzies in Parliament in 1965 as part of the recommendations of the Report on the Future of Tertiary Education.[15] Until this time university research funding had been funded mainly by the States (a more detailed analysis of research funding to universities is given in section 2.1 below).

A further $12m was allocated to rural research and development through Special Appropriations. These are listed in the budget papers as departmental appropriations under the Acts which authorise monies to be held in the Trust Accounts. So, for example, $3.1m was to be paid from the Consolidated Revenue Fund into a trust account under the Wool Industry Research Act 1962-64. Similar appropriations are listed for meat, dairy produce, wheat and cattle and beef research.[16] The proportions for these allocations are:

Wheat Research Act No. 22 of 1957	10.12%
Dairy Produce Research Act 1958-65	10.93%
Cattle and Beef Research Act 1960-64	13.33%
Meat Research Act 1960-65	16.08%
Wool Industry Research Act 1962-64	49.53%

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14 A broad understanding of research and development is used here in keeping with the Hawke Government's belief that science and technology policy should encompass all the activities of the 'funders, performers and producers' of research whether it be of an economic or a cultural nature (*Science and Technology Budget Paper no. 7 1990-91,* p. 2.). Consequently the provision of extension services and environmental measures in 1965 are considered to be part of the cost of the production and use of scientific knowledge as they are in 1990.

15 Committee on the Future of Tertiary Education in Australia. *Report,* 1965.

16 Australia, *Auditor-General's Report & Treasurer's Statements of Receipts and Expenditure,* Parl. Paper 312, 1964-66, vol. VI, pp. 853-855, Table 5; and
Commonwealth Payments to or for the States, Parl. Paper 185, 1964-66, vol. VII, pp. 705-709, Table 5.

Apart from the ARGS research grant allocation, the only non-rural research to be funded from other appropriations was nuclear research. The Commonwealth government allocated $9.6m to the Australian Atomic Energy Commission in 1965-66.[17]

In 1990 estimated funds appropriated by specific purpose grants for research and development totalled $276m. An additional $306m was appropriated by special appropriations for the primary industry research agencies under their various enabling Acts.[18] These two sets of appropriations together comprise 26 per cent of the appropriations for research and development in Appropriation Acts 1 and 2 in 1990. This compares with 23 per cent in 1965 indicating that indirect appropriations continues to be a major means of authorising funds for the production and use of scientific knowledge.

The large proportion of funds (52 per cent) for primary industry research corporations and trusts is appropriated through special appropriations and is divided in the following way:

Aus Meat & Livestock R&D Corporation Act 1985	9.34%
Coal Research Assistance Act 1977 (a)	2.40%
Fishing Industry R&D Act 1987	0.31%
Horticultural R&D Corporation Act 1987	1.33%
Primary Industries & Energy R&D Act 1989	16.83%
Rural Industries Research Act 1985 (a)	3.35%
Wool Marketing Act 1987 - Promotion & research	66.43%[19]

Wool marketing and research receives the largest level of government funding through special appropriations and this amount is a larger proportion than in 1965 (50 per cent). However, it is interesting that the use of Special Appropriations as a funding mechanism has not expanded beyond that of Commonwealth government contributions to rural research corporations. An additional 7 per cent of other research and development appropriations is allocated to rural industry in the form of Specific Purpose grants to the States. This is a slight increase on the proportion allocated for this purpose in 1965.

The use of Specific Purpose Grants has been amplified considerably since 1965 with an introduction of grants to environmental concerns (12 per cent) and secondary industry promotion (2 per cent).[20] The funding of environmental programs in this

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17 In the budget paper *Estimates of Receipts and Summary of Estimated Expenditure,* under the sub-title of 'Other Details of Estimates', Table 9, are given the details of funds for the Australian Atomic Energy Commission. It is not clear how this is related to the $8m allocated to the Commission through the Department of National Development under Appropriation Act 1. *Estimates of Receipts and Summary of Estimated Expenditure,* vol. VII, p. 719, Table 9. *Advance to Treasurer - Statement of Expenditure,* vol. V, p. 573.

18 *Budget Paper no. 2, The Commonwealth Public Account 1990-91* pp. 1.

19 Ibid., pp. 40-50.

20 In 1987 the Commonwealth Government established, on a matched-funding basis with the States, the National Industry Extension Scheme (NIES). NIES offers small and medium-sized businesses in secondary industry the services promoting innovation, efficiency and export -orientation that have for so long been a feature of primary industry in Australia.

way reflects increasing Commonwealth government involvement in this area of States' responsibility. Such programs now total nearly $43m in payments to the States.[21] The grants for 1990-91 are:[22]

Soil Conservation	42.88%
Assistance for water & sewerage	16.99%
S-W Tasmania-Heritage Area	13.67%
Wet Tropics Queensland-Heritage Area	9.34%
Environmental restoration	7.01%
Rainforest conservation	6.79%
Afforestation program	3.32%

Increased funding for environmental concerns occurs in other areas of Commonwealth government funding. Analysis of the functional budget allocations given in *Budget Paper No. 1* reveals that, for example, funding for the National Estate and Parks sub-function has more than doubled in real terms in the 1980s; and that seven of the ten items listed under sub-function '8D General and Scientific Research' are for research and development into areas such as Kraft pulp mills and Cape York land use.[23]

University research continues to be funded through Specific Purpose grants. In 1988 the ARGS scheme for funding university research was replaced by the Australian Research Council (ARC) and the amount of funds distributed in the new scheme was augmented by funds taken from university operating grants. In 1990-91 ARC grants account for 27 per cent of all Specific Purpose and special appropriations.

The Australian Atomic Energy Commission, which was funded by 'other' appropriations in 1965, has been renamed the Australian Nuclear Science and Technology Organisation (ANSTO) and is funded in 1990-91 by appropriations to the Department of Industry, Technology and Commerce under Appropriations Acts 1 and 2. In real 1990 values this represents a fall from $84m to $60m.

The pattern of broad research fund allocation outlined above shows that the most significant change has been the diversification of fund destination in terms of portfolios. This has largely been at the expense of defence and nuclear research. The level of funds for rural research have stayed high. The main winners have been medical and manufacturing research. This indicates that the policy rhetoric of techno-economistic ideology for science policy reality has been transformed into the policy reality of resource allocation.

Department of Industry, Technology and Commerce, *Science and Technology Statement 1987-88,* AGPS, May 1988, p. 109.

21 Environmental funds such as the $33m appropriation for South West Tasmania have not been included because there is no evident scientific component in the activity to which they have been allocated.

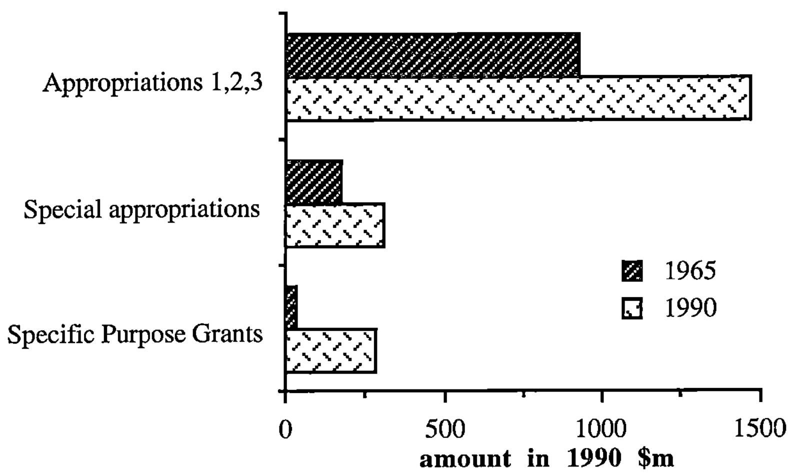
22 The percentages have been calculated from data in *Budget Paper no. 4,* pp. A30-A34.

23 *Budget Paper no. 1: Budget Statements 1990-91,* pp. 3.22 & 3.197.

Summary of total appropriations 1965 and 1990

Figure 5.5 illustrates the estimated total appropriations for 1965 and 1990. In 1965 an estimated $137m was spent by the Commonwealth government on research and development. This is the equivalent of $1136m in 1990 values. Using similar methods of calculation for this thesis the total obtained for 1990 is $2058m, an increase of 55 per cent.[24] This indicates a greater value placed by government on the benefits of research, and in particular towards manufacturing industry. However, 'snapshot' allocations for widely separated years, while having immediate impact, do not reveal consistent trends. The following section unpacks the intervening years and looks in more detail at particular research agencies.

Figure 5.5: estimated total appropriations for research 1965 and 1990



Data source: *Parliamentary Papers,* 1964-66, vol.. V, pp. 517-819; vol.. VI, pp. 853-855;
Parliamentary Papers, 1964-66, vol.. VI, pp. 853-855;
Parliamentary Papers, 1964-66, vol.. VII, pp. 493-499; pp. 705-709; vol.. VII, p. 719.
Budget Paper No. 2: The Commonwealth Public Account, 1990-91, pp. 40-50
Budget Paper No. 4: Commonwealth Financial Relations with Other Levels of Government, 1990-91, Table 9, pp. 196-201.

2. Funding for Major Research Agencies

The above analysis of appropriation allocations reveals the difficulties of obtaining longitudinal comparisons of government activity in scientific production when the components of the portfolios change through time. Comparing the Departments of Primary Industry in 1965 and 1990 would require excluding the Energy component of the 1990 portfolio, or adding to the 1965 portfolio elements of the Department of National Development. However, individual agencies have remained more consistent.

24 The data were obtained by identifying allocations to research in the appropriation bills in 1965 and then using similar allocations for 1990. Consequently the estimates for 1990 given above do not include areas which were not funded in 1965. For example, in 1990 the estimated total in the*Science and Technology Budget Paper No.6* is $2422m, or over twice the amount in 1965. This amount, however, includes revenue foregone through the 150 per cent tax concession. In 1965 the 100 per cent tax concession allowed would not have been included in any formal estimate of research and development funds.

Figure 5.6 illustrates the allocations to the eight major research agencies since 1965. The allocations have been changed into 1990 dollars to allow a more realistic comparison.

There are two agencies which have dominated research and development funding since 1965: CSIRO and DSTO. Defence research declined sharply after 1972 and has been decreasing ever since (the rise in 1979 is probably due to a disjunction in data).[25] This reflects the decline in colonial and nationalistic ideology as a rationale for science funding. The figures used for CSIRO are the appropriation funds only. External funds (or 'contributions' as they were known until the mid 1980s) have not been included above but will be discussed in section 3.2 below. Commonwealth government funds for CSIRO have increased steadily so that appropriation funds in 1990 are almost double the 1965 figures in real terms. The most dramatic increase in the 1980s has been the introduction of the tax concession which, at $376m of revenue foregone in 1990, is almost equivalent to funding another CSIRO.

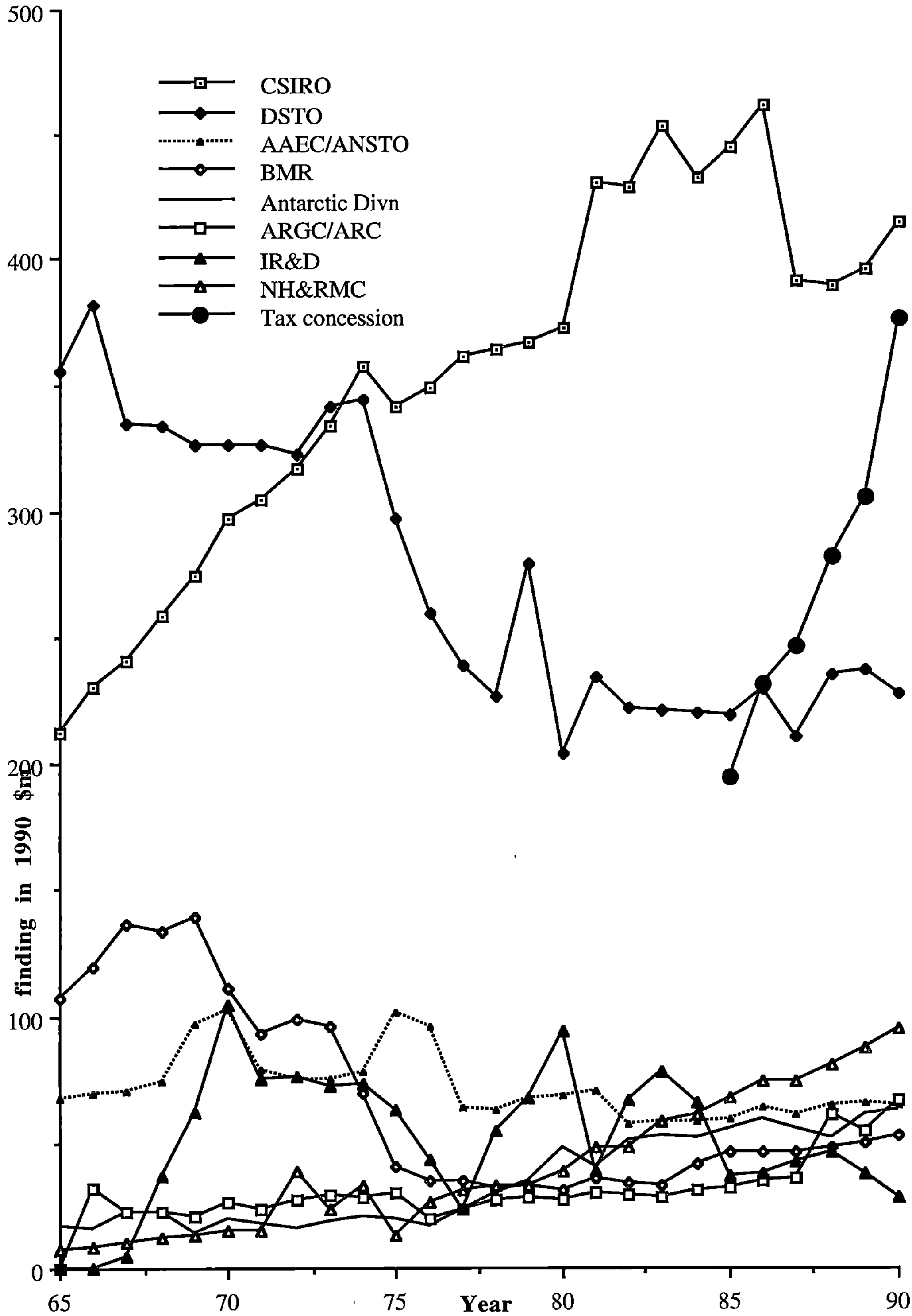
The decreasing funds for AAEC/ANSTO reflect the falling expectations of nuclear power and the inability of the pro-nuclear science lobby to maintain its influence over funding decisions. The high early funding for the Bureau of Mineral Resources is probably due to the oil and other mineral exploration work undertaken by the Bureau in the late 1960s and 1970s. The downturn in IR&D grant funding must be offset against the foregone revenue under the tax concession introduced in 1985. Grants for research in the higher education system remained stable in real terms until 1987 when they were increased by funds tranferred from university recurrent funding.

The second highest single agency funding increase has been that to the NH&RMC (indicated in the graph by a white square). However, this position is being challenged by the Cooperative Research Centres (CRCs) which, by 1993 had reached an equivalent level of funding to the NH&RMC in 1990. By 1996 funding for CRCs will reach $130m in 1990 values.

This set of data allows an interesting insight into the pattern of funding over the twenty-five year period. If the total resources spent on the agencies and programs included above (excluding the tax concession) are calculated in 1990 values for each year, the totals range from $760m in 1965 to $917 m in 1990. The highest allocation

[25] There are considerable difficulties involved in finding longitudinal funding statistics which are consistent. For example, figures for the allocation of funds for research and development in the Department of Defence for 1979-80 are given as $90m in the 1990-91 Science and Technology Budget Related Paper; $93m in an Independent External Review of DSTO for 1979-80 (Parl. Paper 201, 1981); $120m in the estimates reported in the Defence Report 1979-80; $126m in the Science and Technology Statement 1980-81, and are not mentioned at all as actual expenses for 1979-80 in the Defence Report 1980-81. Similarly, in the mid 1970s under both the Whitlam and Fraser Governments, budgets for the smaller agencies simply disappeared from the Annual Reports of their Departments and from the Auditor-General's Budget Report. Consequently figures had to be taken directly from Appropriation Papers and therefore may not represent the complete budgets of the agencies.

Figure 5.6: Appropriations for major research agencies and programs, 1965-1990, in 1990 $m



Data source: CSIRO *Annual Reports,* 1965-1990;
Science and Technology Budget Statements, 1989-93;
ARGC/ARC *Annual Reports,* 1965-1990;
AIRD/AIRDIS/IR&D Board *Annual Reports,* 1966-1990;
AAEC/ANSTO *Annual Reports, 1965-1979;*
NH&MRC *Annual Reports,* 1965-1979.

was in 1974 when the value in real terms was $971m and the lowest was in 1965. Given the limitations of the data (that only the 8 largest agencies and programs are included, and that the data sets are not continuous through time), it would appear that the proportion of public funds allocated to research and development in the agencies has remained remarkably stable in real terms over the past twenty-five years.

What has changed significantly is the distribution of funds between agencies, and the way in which the funds are controlled. When the tax concession and CRC funding are added in, the total amount has almost doubled since 1965. Significantly, control over these new funds is placed in the Department of Prime Minister and Cabinet (CRCs) rather than DEET; and jointly between the Australian Tax Office (ATO) and the IR&D Board (the tax concession). This enhances the control of the core executive and the science policy superstructure over funding for research and development.

3. Funding in the Subsystems of Science

Resources for the science system have traditionally been allocated in two forms: funds for research agencies and funds for research programs. The following section amplifies the above analysis by examining in greater detail the changing patterns of resource allocation to key research agencies and programs in the four science subsystems corresponding to the four science policy subgovernments analysed in chapters three and four. This closer analysis is intended to reveal changing objectives for research from notions of scientific knowledge created for its own sake to science created for economic ends; and changing patterns of control as governments demand greater accountability from scientists for the public funds they use.

3.1. Higher education

The implementation of the Murray (1958) and Martin (1965) Reports moved financial control of universities from State Governments to the Commonwealth government.[26] The Commonwealth government also assumed responsibility for the allocation of resources to both general and specific research activity.[27] Since 1965 the Commonwealth government has provided general funds for research in the form of a designated proportion of the block grant allocated to the Australian Universities Commission (later the Tertiary Education Commission, and then the Higher Education Council of the National Board of Education, Employment and Training).[28] These general research funds are of less use for science policy analysis than the individual research grants because the pattern of their internal allocation to the various scientific

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26 Committee on Australian Universities, *Report,* Government Printer, Canberra, 1957.
Committee on the Future of Tertiary Education in Australia, *Report,* 1964-65.

27 It was not until 1973 that the Commonwealth Government assumed complete responsibility for funding general research in universities.
ASTEC, *Science and Technology in Australia 1977-78,* vol. 2, p. 51.

28 Ibid., p. 65.

disciplines cannot easily be traced. Analysis of the funds allocated to foster individual research provides a more useful indicator of changing governmental objectives for the higher education sector in the production of scientific knowledge because the areas of the science system to which they are allocated can be traced, and because changing patterns of government intervention can be identified.

3.1.a Australian Research Grants Scheme in 1965

The establishment of the ARGC in 1965 was a direct response by Menzies to concerns expressed in the Martin Report about the low level of funding for research available to scientists in Australian universities. Martin, Chairman of the Australian University Commission and also Chairman of the Committee on the Future of Tertiary Education in Australia, had trained in the Cavendish Laboratory, Cambridge under Rutherford, and was a firm believer in the British tradition of universities as centres of research excellence in pure rather than applied science. He had recommended that $10m should be made available in 1965-66 for research in all universities in Australia at postgraduate level.[29] Half these funds would come from the States and be matched by Commonwealth government allocations. Menzies subsequently announced that an advisory committee would be set up to distribute grants from the Commonwealth government to individuals or research teams subject to matching funds being awarded by State governments.[30]

The ARGC was responsible to the Minister-in-Charge of Commonwealth Activities in Education and Research. The Committee was allowed to establish its own rules and procedures with its only departmental liaison being through the Department of Prime Minister and Cabinet for administrative support. Grants were decided on the individual merit of each proposal with no prioritisation of disciplines, States or universities.

3.1.b The development of the ARGC in the 1970s

By 1967 the ARGC was funded totally by the Commonwealth government and by 1972 the Committee was overseen by the Department of Education and Science. The Committee was enlarged from the original 10 members to 18 in 1973 in order to provide a 'broader range of knowledge and experience'.[31] Members sat on the Committee on a rotating system. A larger group of 35 former members was also available to provide specialist advice.

In 1972 Fraser, as Minister for Education and Science in the McMahon government, began to prioritise grants. He earmarked $3m, of the $20m allocated to the ARGC for 1973-75, for four specified areas of research: upper atmosphere

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29 Australian Universities Commission, *Third Report 1964-69,* Parl. Paper 330, Canberra, 1964--66, p. 668, section 4.6.

30 Australia, House of Representatives 1965, *Debates,* vol. HR45, pp. 267-274.

31 ARGC, *Report for Triennium 1973-75,* Parl. Paper, 285, Canberra, 1976, p. 1.

science; the acqusition of a nuclear resonance spectrometer; multi-disciplinary research; and marine science. In 1979-80 the Marine Sciences and Technologies Research Grants Scheme, worth $0.4million in the first year and $2m a year thereafter, was added to the list of funding sources also available to researchers in the universities.

Apart from these minor changes, at the end of the Fraser government in 1983 the ARGC was remarkably unchanged in structure and process from the position in 1973. When ASTEC was established in 1977 it had argued that, because of the large increase in the number of professional staff capable of undertaking research in the university system, ARGC funds had diminished in terms of the funds available per potential researcher.[32] There was no response from the government and 1980-81 funds were allocated on the basis of the maintenance of real value. Interestingly, while ASTEC (and a majority of the public sector scientists on ASTEC were currently or had been at some time members of the ARGC) perceived ARGC grants to be funding fundamental research, the Department of Science saw the scheme as stimulating 'basic, pure and applied research of the highest excellence in non-government institutions'.[33] Jones, who became Minister of Science in 1983, also considered that ARGC should fund the complete spectrum of types of research in universities. The differences seem to lie in the fact that the ARGC saw the grants as unattached and Minister Jones perceived relevance to socio-economic objectives as an integral aspect of university research.[34]

3.1.c The transformation of ARGS in the late 1980s

The Hawke government began its relationship with the ARGC by requiring the Committee to implement some of the recommendations of the 1978 ASTEC Report. Consequently, the 1984 ARGS Report announced a four-part categorisation of grants designed to nurture young scientists and the processes of research in universities as well as funding the usual areas of research strength.[35]

However, the government expected the changes to be made within a steady state of resources. Funding for the scheme in 1985 was increased by only 6.5 per cent to $23.8m. The Committee complained bitterly that the 1226 projects to which it had awarded grants in 1985 should have been allocated $49m to be undertaken effectively. An additional $6m should also have been provided to implement the government's initiatives announced in 1984. In order to cope with the increased demand for funds and the implementation of new initiatives the Committee introduced the concept of the 'nil grant'. Projects awarded a nil grant were assessed as being worthy of support but as there was no money in 1985 these projects would have first consideration in

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32 *Science and Technology in Australia 1977-78,* vol. 2, p. 64.
33 Department of Science, *Science and Technology Statement 1980-81,* p. 77.
34 The Hon Barry O. Jones, 'Government funding of scientific research', *Vestes,* no. 2 1985, pp. 4-10, p. 8.
35 ARGC *Report on Grants Approved for 1984,* Parl Paper 151, Canberra, 1984, pp. 6-7.

1986.[36] In the opinion of the Committee basic research funding in Australian universities was being devalued in favour of research funded through such other agencies as the NH&MRC.[37] The Committee also continued to push for the ASTEC recommendation that ARGS should subsidise international travel for scientists.

In 1985 some elements of the Committee's Terms of Reference were changed. The most significant was the requirement that the ARGC should consult CTEC to ensure that funding overlap or duplication was not occurring and that the Committee should redirect applicants whose projects were more appropriately funded by other agencies.[38] The ARGC Reports of 1986 and 1987 continued to emphasise the difficulties of allocating funds which the Committee felt were grossly inadequate to meet the expectations of both the research community and the government. The Committee repeated its plea for increased funding up to $150m a year to provide the human and knowledge resources in science needed if the standards of 1965 were to be achieved. In 1987, despite funding increases of 36 per cent over the previous two years, the Committee had decided to fund urgent equipment purchases rather than to increase grants to meet rising costs.[39]

3.1.d The ARC and the rationalisation of research funding

In 1987 ASTEC reported to the Prime Minister that the existing fragmented system of funding higher education research should be scrapped and replaced with a single council responsible for overseeing a more comprehensive and competitive system of research funding for higher education. In the Report, which ASTEC claimed was based on extensive consultation with the scientific community in all sectors of operation,[40] ASTEC recommended that the basic premises upon which the new council would distribute its funds should encompass not only excellence but also accountability and relevance to socio-economic objectives.[41]

The government approved the establishment of the Australian Research Council (ARC) which was to be directly responsible both to the National Board of Employment, Education and Training (NBEET) and to the Minister for Education.

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36 ARGC *Report on Grants Approved for 1985,* Parl Paper 123, Canberra, 1985, p. 3.

37 Ibid., p. 7-9.

38 Ibid., p. 1.

39 ARGC, *Report on Grants Approved for 1987,* Parl. Paper 93, Canbera, 1897, p. 4.

40 Assistant Professor Ian Lowe of Griffith University disagrees. He considers that ASTEC decided in advance of consultations what their recommendations would be. He says:

> When ASTEC came here to air their views when they were partway through their studies on higher education funding they were'nt really interested in consulting people but in propounding their views which were that you need to concentrate funds to achieve critical mass and support the best researchers. Their view was that the reason we in Australia lag behind other countries is that we are a small country and we can't afford to research across the board. We have to concentrate resources on the best workers.

Interview, 1.11.89.

41 ASTEC, *Improving the Research Performance of Australia's Universities and Other Higher Education Institutions,* p. 2.

The new Council was to be responsible for administering all the higher education grants schemes, shown, with their 1990 allocations, in Table 5.1.

Table 5.1 ARC Funding for 1990

	1990$m
ARC Research Grants	66.4
Research Fellowships	9.5
Special Research Centres	9.2
Key Centres of Teaching and Research	6.7
Australian Postgraduate Awards	35.8
Research Infrastructure	25.7
Assistance to Technological Institutions	1.3
Large Equipment	1.0
NH&MRC	4.4
Evaluation	0.4
TOTAL	*161.6*

Source: ARC, *The Australian Research Council Awards 1990,* Parl Paper 317, 1990, Canberra, p. 6.

Under the Higher Education Funding Act 1988, funds for the new competitive system were increased by transferring, to the ARC, some of the research funds previously allocated through operating grants to individual universities.[42] The re-distribution (or 'clawback' as it became known) was effected in two stages. Firstly, between 1988 and 1991 $60m was transferred from operating grants to ARC funds.[43] Secondly, $150m, or 6% of the research component of operating grants, was transferred to the ARC to be redirected to the universities on the basis of the proportion of funds allocated to each university through the competitive granting system. In 1990 funds totalling $162m were allocated to the ARC to be redistributed through the above ten programs.[44,45,46] The shift from block funding to itemised program funding indicates a greater degree of control of research in tertiary institutions by the higher education subgovernment. Figure 5.7 illustrates the change.

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42 Australian Research Council (ARC), *The Australian Research Council Awards 1990,* Parl. Papers 1990, no. 317, pp. 1-5.

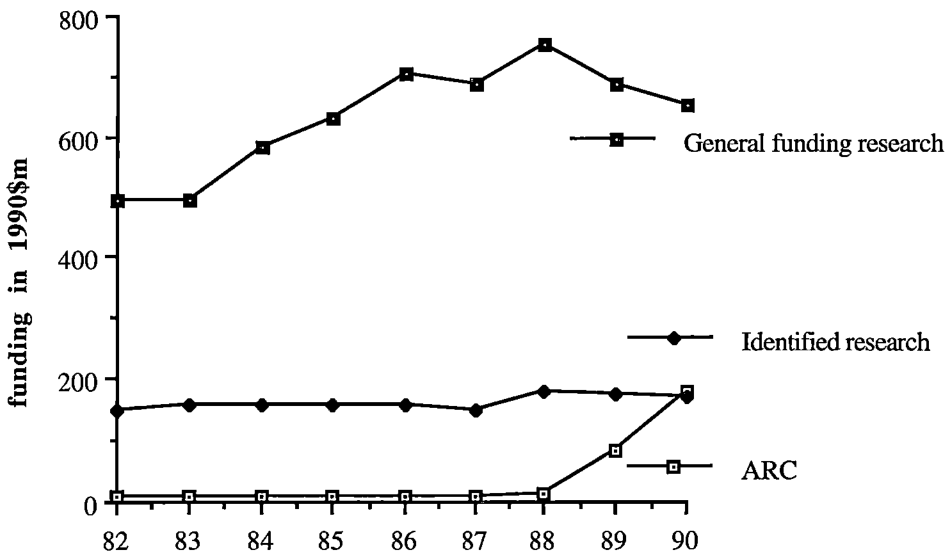
43 Department of Education, Employment and Training, *A New Commitment to Higher Education in Australia,* AGPS, Canberra, 1988, p. 12.

44 The NH&MRC component is part of a re-distribution of the research component of university operating grants.
Ibid., p. 6.

45 According to the 1990 ARC Report the infrastructure grant of $26m is 'new' DEET money.
Ibid., p. 8.

46 The Australian Postgraduate Awards also became the responsibility of the ARC in 1988 and new funds totalling $57m over five years were announced in the 1989 May Science and Technology Statement.
Australia, *Science and Technology for Australia,* p. 26.

Figure 5.7: Higher education research funds, 1982-90.



Data source: Science and Technology Budget Statements, 1993-94, p.40.

The graph shows the enormous increase in the proportion of competitively awarded funds for research in higher education. This increase has been at the expense of university research formerly awarded funds from operating grants by internal evaluation. The funds are now allocated to research projects judged to be excellent by external evaluation. This process of evaluation will be discussed further in chapter 7.

The ARC also now has a statutory obligation to select and support certain fields of research in preference to others on the grounds of relevance to national economic objectives as well as to the traditional criterion of scientific excellence.[47]

One of the most persistent conflicts in the higher education science policy community has been over the level of funding for research. The above figures show that there was a massive increase in real terms of ARGS/ARC funding between 1982 and 1990.[48] At the time of the 'clawback' changes in 1987-88 there was an uproar of dissatisfaction from researchers in the attentive public of higher education, but was this justified? The following section places the changes in the context of the period from 1965 to 1990 and examines how they have affected research in the higher education system.

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47 ARC, *The Australian Research Council Awards 1990,* p. 1.

48 If 1993 budget data for the period are translated into 1990 values the percentage increase is:

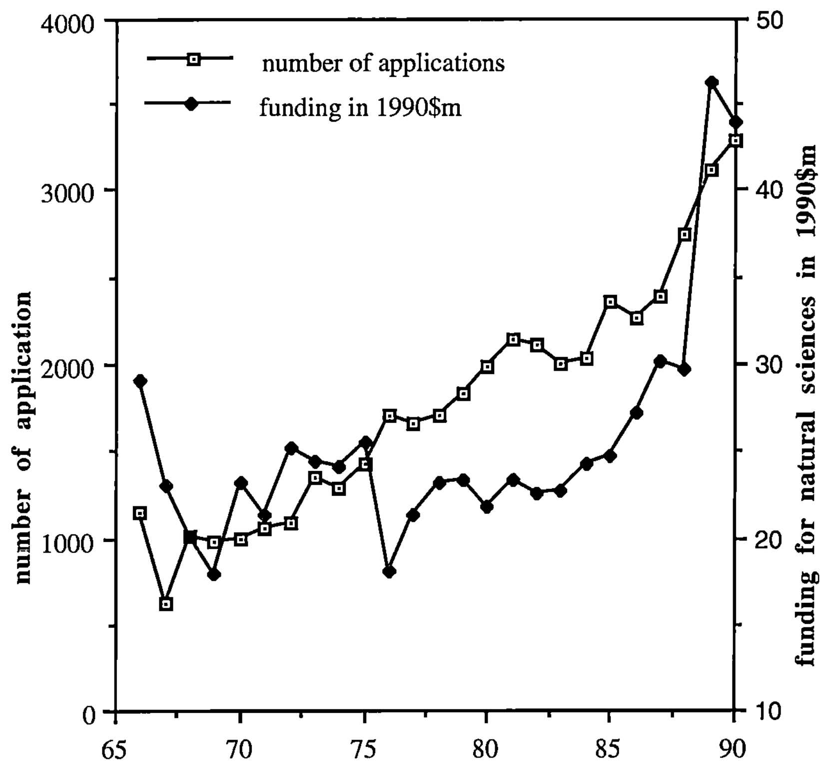
ARC funds	1797%
Identified research funds	13%
general research	31%

Australia, *Science and Technology Budget Statement 1993-94,* AGPS, Canberra, 1993, Table 6, p. 40

3.1.e Supply and demand for higher education research funding

Figure 5.8. shows the the relationship between the *number* of scientists applying and the overall real level of funding between 1965 and 1990.

Figure 5.8: the relationship between the number of applicants and funding for ARGC/ARC grants for the natural sciences, 1966-90.



Data source: ARGC and ARC Reports, 1965-1990.

The graph illustrates the relationship between funds awarded for research in the natural sciences through the ARGC/ARC schemes from 1966 to 1990 in 1990 dollars, and the number of applicants for these funds.[49] In 1966 there were approximately 3000 scientists working in the natural sciences in universities in Australia.[50] Of these scientists 909 applied for ARGS grants and 326 (36 per cent) were successful in obtaining grants averaging $91,000 in 1990 values.[51] Until 1975 the pattern of

[49] The graph includes only those grants awarded on the traditional basis of excellence for individual projects and does not include the supplementary grants introduced in the late 1980s.

[50] Lamberton gives Bureau of Census and Statistics estimates that in 1965 there were 40,468 scientists in Australia. He claims that 4 per cent of engineers; 13 per cent of chemists and 50 per cent of physicists were working in Australian universitities. This proportions give a total of 3255 scientists. However, Lamberton offers no data on Agricultural Scientists or Biologists. Lamberton, *Science, Technology and the Australian Economy,* pp. 70-71.

Project Score figures for scientists in universities in 1969 are given as 4,450 for the natural sciences. Of these 2,308 were professional scientists; 923 were sub-professionals and 1,219 were classed as 'other'.

Department of Science, *Project Score Report 3: Research and Development Expenditure by Higher Education Sector 1969,* p. 37.

[51] In this first round of allocation the grants were high because of the relatively low number of applicants considered bt the Committee to be of sufficient standard.

increase in funds and the pattern of applications are roughly similar. In the decade from 1975 to 1985 there is a dramatic separation between the increasing number of applications and the decrease in the real level of funding. In 1974 1004 natural scientists applied for grants and 735 (74 per cent) were successful. The average grant was $27,300 in 1990 values.[52] This success rate would account for the scientists' memory of 1974 as the golden year of ARGC funding and for the increasing antagonism between scientists and governments about the level of higher education research funding in later years. In 1981, 1579 natural scientists applied for grants and 1044 (68 per cent) were successful, but the average grant was only $20,239 in 1990 values.[53]

It is only in the 1980s that there has been a dramatic increase in the funds awarded in comparison with the number of applicants. In 1990 the ABS estimates that there were 19,000 natural science researchers in the higher education sector.[54] In the natural sciences 2429 researchers had applied for $186m, and $44m was awarded to 1059 (44 per cent) successful applicants.[55] The average grant was $42,222 or over twice the amount of 1981 in real terms. If other grants such as the small project grants, equipment grants and career fellowships which are now also awarded by the ARC were also to be taken into account the change would be seen to be even more dramatic.

The pattern of change is one of a greater number of natural science researchers competing for the same number of grants which have doubled in average size. The success rate has gradually diminished since 1974 and dramatically so since the mid-1980s as more university research is funded through the competitive scheme.[56] It is obvious that the minority who receive grants will be happier than the majority who were unsuccessful. As the ARC funds have increased, the selection committees have chosen to give larger average grants to fewer researchers. What is also of interest is the changing pattern of the internal allocation of resources among the scientific disciplines. The question is one of whether the same areas of science are being funded

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These figures exclude applications and grants for the Social Sciences and Humanities. ARGC, *First Report,* p. 2.

52 ARGC, *Report 1973-75,* pp. 146-147.

53 ARGC, *Report 1981,* Parl. Paper 33, Canberra, 1981, pp. 8-9.

54 ASTEC estimates from ABS Research and Experimental Development data that there were 11,384 professional researchers in the higher education sector in 1986-87. ASTEC, *Profile of Australian Science,* AGPS, Canberra, 1989, p. 367, Table 2-2. However, ABS figures for 1988-89 indicate that there were 19,318 such researchers. This figure is used. ABS, *Research and Experimental Development All Sector Summary 1989-90,* Cat no. 8112.0, 1990, p. 3.

55 The text of the 1990 ARC Report states that 1350 successful applicants for large research grants were awarded $53.1 million. However, Tables 1 & 2 show that 1357 successful applicants were awarded $51.9 million. These figures have been used for compiling Figure 5.13 below. ARC *The Australian Research Council Awards 1990,* p. 17 & pp. 44-48.

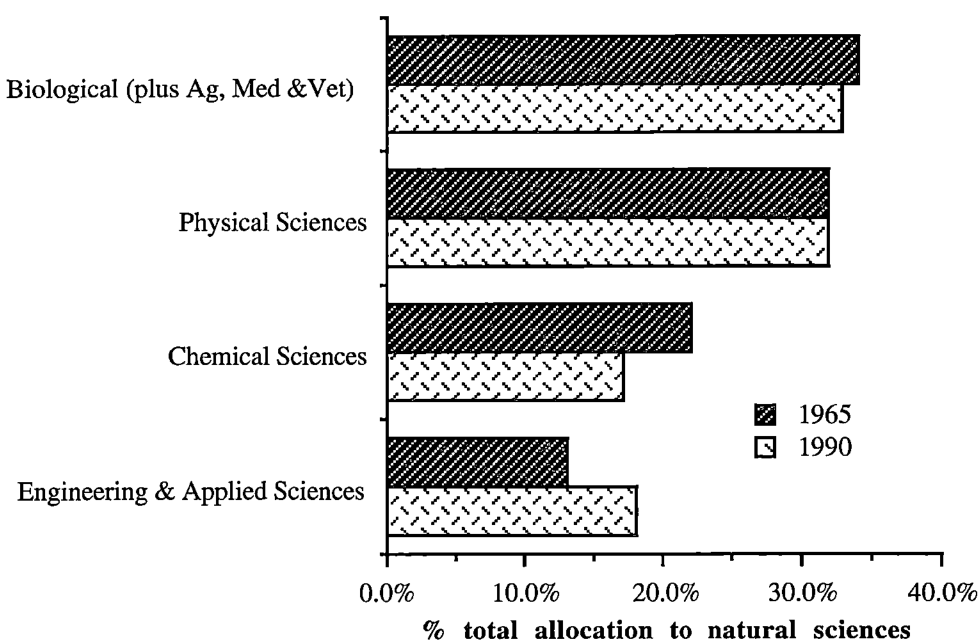
56 It must be remembered that in 1990 the ARC grants covered the whole of the unified national system of universities which includes former colleges of advanced education, and that universities are now expected to encourage researchers to apply for ARC grants and produce a 'research profile' which is part of the DEET assessment process.

in 1990 as were in 1965, or has the changing ideology in science policy affected the areas of research funded.

3.1.f The inter-discplinary allocation of ARGC/ARC grants 1966 and 1990

Grants for the natural sciences have traditionally been classified into the five broad categories illustrated in Figure 5.9. However, these broad discpline areas are of little use in identifying patterns of change associated with the socio-economic areas in which the resultant knowledge might be used. For the purposes of comparison in this section the 1990 data have been re-classified into 1966 categories and vice versa. Figure 5.9 indicates that the distribution of grants has changed very little since the grants began in 1966.[57] Grants to the Physical Sciences have stayed constant at 32 per cent. Biological Sciences have dropped by 1 per cent to account for 33 per cent of funds. The allocation for Chemical Sciences fell by 5 per cent and that for Engineering and Applied Sciences increased by the same amount. Apart from these latter categories the interdisciplinary picture has not changed significantly.

Figure 5.9: ARGC/ARC grants by 1966 categories

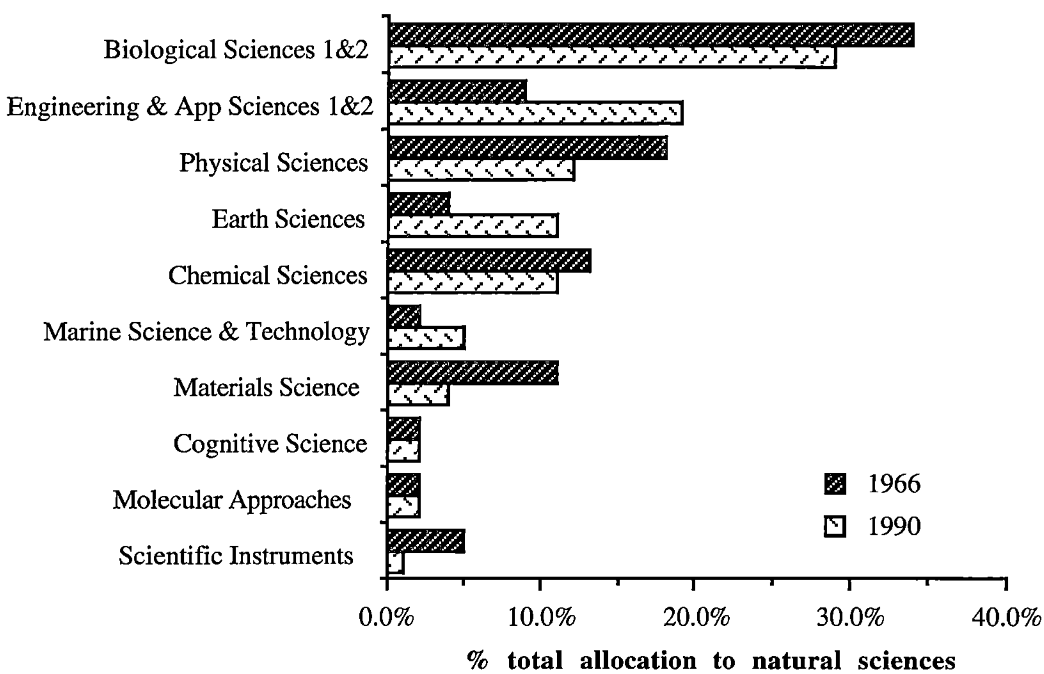


Data source:	ARGC, *First Report,* p. 2.
	ARC, *The Australian Research Council Awards 1990,* pp. 53-58.

57 The 1990 ARC Report has two graphs illustrating the distribution of discipline grants (pp. 61-62). One of these graphs roughly corresponds to the 1966 categories, the other illustrates priority grants distribution. Since it is not indicated whether the data for the priority grants has been included in the broader category data these figures are not used in Figure 5.7 The author compiled a separate spreadsheet which assigned each of the grants detailed in the specific categories on pp. 53-58 to the 1966 broad categories.

The 1966 categories are very broad and the way in which scientific work is described and identified has changed considerably. For example, in 1966 there was no recognition that Earth Sciences were distinct from physical, chemical or biological sciences. Molecular biology was in its infancy and the science of the behaviour of different materials was studied in Departments of Chemistry, Physics and Engineering. A more detailed picture has been sought by re-classifying the five 1965 categories for the natural sciences into the twelve more specialised categories used in 1990.[58] The result is figure 5.10.[59]

Figure 5.10: ARGC/ARC grants by 1990 categories



Data source:	ARGC, *First Report,* Parl. Papers Session 1965-66-67, pp. ARC, The Australian Research Council Awards 1990, pp. 53-58.

The graph shows that by far the largest proportion of grants (29 per cent) is still going to the biological sciences. This proportion is lower than in 1966 when 34 per cent of grants were classified as for Biological Sciences. The difference is probably due to classification. 8 per cent of grants which were classified for Biological Science in 1966 can now be estimated to be classified in such areas as Marine Science and Technology, Materials Science and Molecular Approaches. Obversely, 3 per cent of

58 The four specialised categories for Biological Sciences and for Engineering and Applied Sciences are collapsed into one for each science to simplify the comparison.

59 For a non-scientist this sorting process is complicated by the fact that the 1990 categories are not mutually exclusive. For example, cell membrane studies are funded under the categories Biological Science - Molecular Biology and Cell Metabolism; Biological Science - Plant and Animal Biology, and Molecular Approaches. Similarly, studies of soil and rock mechanics occur in the Earth Sciences, Marine Science and Technology and Materials Sciences. Usually there is enough information in the title of the 1966 project to allow intelligent guesswork about the appropriate 1990 category. However, some misclassification may have occurred.

grants classified in other disciplinary categories would in 1990 have been classified as Biological Science. Within the Biological Sciences in 1966 the largest grants of over $35,000 each went to cell physiology (2) and neurology. In 1990 the largest proportion of grants went to molecular biology, biological energy conversion and the biochemistry of proteins and enzymes; the largest single grant of $45,000 went to a study of electron microscope technology in biology.

The largest increase in grants in 1990 was to Earth Sciences which became a category in its own right in 1970. In 1966 the grants for this category were classified mainly as Physical or Chemical Sciences. The largest grants in 1966 were for seismic strain studies ($18,600), crystallography ($15,500) and the origin of base metal ores in Tasmania ($14,850). In 1990 the largest percentage of funds went to 'other earth sciences' where 12 per cent of researchers in Earth Sciences took 21 per cent of the funds: an average of $80,000 per project. Among the identified subgroups of the discipline the highest average grant of $55,000 went to petrology studies.

Engineering and Applied Sciences also had a larger share of funds in 1990: 19 per cent compared with 9 per cent in 1966. The largest increase was in the category Engineering and Applied Sciences 1 which includes computer systems. Within this subgroup the highest-funded researchers were in fluid mechanics where 17 per cent of the projects received 21 per cent of the funds. They also received the highest average grants of $54,000 compared with a category average of $44,000. In the 1990 ARC Report grants for computer science and electronic control systems have been separated into six subgroups. If these are aggregated they account for 31 per cent of the funds for the Engineering and Applied Science 1 category.

Perhaps the most surprising finding is that in 1966 Materials Science research accounted for a greater proportion of funds than in 1990 despite this being a priority area in 1990. The discontinuity between expectation and result is large enough to warrant detailed justification of the way in which the 1966 grants were re-classified into 1990 categories.

Table 5.2: Re-classification of 1966 grants in Materials Science

1990 Categories	1966 Project titles
Biochemistry & metabolism of microorganisms	Surface bonds
Inorganic & metal chemistry	Grain boundaries in metals
Electrochemistry	Magnetic resonance in minerals
Environmental & analytical chemistry	Low temperature density waves in metals
Polymer & colloid chemistry	Electrical properties of crystalline films
Industrial & mineral chemistry	Heterogeneous polymerization
Mineral processing	Electric & magnetic molecular behaviour
General civil engineeering	Cationic polymerization mechanisms
Soil & rock mechanics	Vinyl polymer molecule size and shape
Fluid mechanics	Block copolymers
Heat & thermodynamics	Metal/metal oxide surface reactions
Electronic devices & circuits	Respiratory organelles of microorgans.
Applied physics	Absorption on mineral surfaces
Condensed matter physics	Surface chemistry in mica clays
Metallurgy & metals	Ionic solid reaction diffusion mechanisms
General chemical engineering	Stress-strain properties in materials
Ceramic & polymer engineering	Mechanics of discontinua
	Technology thin semi-conductor films

Data source: ARGC, *First Report*, pp. 5-15.
ARC, The Australian Research Council Awards 1990, pp. 53-58.

In 1966 a total of eighteen projects could have been classified as Materials Science in 1990. The funds awarded to these projects totalled \$408,334 giving an average grant of \$22,685. In 1990 dollars these sums would be \$3.2m and \$180,000 respectively. By contrast in 1990 the total spent on this priority category was \$1.59m with an average grant of \$49,600.

A similar situation exists for Scientific Instrumentation. Table 5.3 shows the way in which the 1966 grants can be re-classified into 1990 categories. Only projects involving the development of instrumentation techniques are included.

Table 5.3: Re-classification of 1966 grants in the category Scientific Instuments and Instrumentation

1990 Categories	1966 Project Titles
Environmental & analytical chemistry	High voltage electron diffraction
Medical chemistry	Transmission specimen stages electron micros.
Sedimentology	Mass spectrometry in Geology and Chemistry
Communications	High resolution NMR spectrometer studies
Applied physics	Mass spectrometric studies
Accoustics & optics	Low temperature spectroscopy
Instruments & techniques	Infra red spectroscopy
	Absorbed molecule spectroscopy

Data source: ARGC, *First Report*, pp. 5-15.
ARC, *The Australian Research Council Awards 1990*, pp. 53-58.

In this category again the level of funding in 1966 was considerably higher than in 1990. In 1966 the average grant was \$20,600 and the total spent was \$163,900. In

1990 dollars these amounts would be \$164,000 and \$1.3m respectively. In 1990 the average grant was \$46,000 and the total spent a meagre \$368,000.

3.1.g Summary of higher education resources

The pattern of resource allocation which has emerged from the above analysis is one of decreasing autonomy for individual universities in the allocation of their diminished research resources, and increasing superstructural subgovernment control of the funding of specifically targeted priority area programs of research. Through the ARC the superstructure now controls a vastly increased envelope of research resources which they have chosen to allocate according to different patterns of distribution: rewarding more researchers now compete for a higher average level of grant. Although the total amount of resources allocated to higher education research has increased quite markedly, there is greater dissatisfaction because the majority of applicants are unsuccessful.

Nevertheless, the two specific examples of Materials Science and Scientific Instrumentation raise questions about whether the ARC is in fact allocating resources to government-nominated priority areas or whether in fact projects are simply reclassified to conform with government rhetoric about priority areas. Why, for example, there are two subgroups of polymer and colloid chemistry; one in the Chemical Sciences and one in Materials Science?[60]

The system would seem to allow for obfuscation which favours the scientists. Considerable scientific expertise is necesary to unravel the pattern of resource allocation and so governments are dependent upon the scientists on the subgovernmental selection committees to ensure that the criteria of prioritisation are strictly applied when choosing among projects. This aspect of funding for higher education research seems to offer an example of Wright's congruence of ideologies hypothesis discussed in chapter one. Wright argues that subgovernmental actors cannot always control particularistic behaviour by the imposition of general norms.[61] In this instance researchers may be using the policy rhetoric of priorities in order to avoid the sanction of not receiving funding while actually continuing previous patterns of research.

The difficulty of accountability at this micro-level of resource allocation in the science policy community is part of, and contributes to the inherent tension between scientific values and political values. This is particularly so in higher education basic research in which the distinction between disciplines and areas of research may be blurred. In CSIRO, where the research is intended to be of a more applied nature, the areas of funding should be clearer. The following section examines changing patterns of funding to, and within, the Organisation between 1965 and 1990.

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60 ARC, *TheAustralian Research Council Awards 1990,* pp. 54-55.
61 Wright, 'Policy Community, Policy Networks and Comparative Industrial Policies', p. 596.

3.2. Funding for CSIRO

In 1965 CSIRO was still the Commonwealth government's 'principle chosen instrument' for civilian scientific research.[62] Changes were beginning to be made to the provision of federal public funding for the production of scientific knowledge in the secondary industry and academic sectors of research but decision-makers in CSIRO controlled to a large extent the direction of non-miltary scientific research in Australia, and their focus was primarily on research for primary industry. The most significant changes in the funding of the production of scientific knowledge in CSIRO between 1965 and 1990 have been: the requirement that up to 30 per cent of CSIRO's total budget should be generated from outside direct government funding; the increased financial accountability of the Organisation to the government; and the changed focus in scientific activity which accompanies CSIRO's location in the Department of Industry Technology and Commerce.

3.2.a CSIRO's share of the federal budget

The proportion of funds for research and development allocated to CSIRO has changed relatively little over the 25-year period. In 1965 CSIRO received 24 per cent of the research and development funds allocated in Appropriations 1 and 2, and in 1990 the Organisation received 27 per cent. Compared with the allocation for defence science which fell from 36 per cent to 14 per cent; and the allocation for medical research which increased fourfold, the allocation of resources to CSIRO has remained fairly consistent. The two major sources of funding for CSIRO are appropriations and external 'contributions' from public and private sector organisations sponsoring the production of scientific knowledge. Figure 5.11 shows the relationship between the two types of funding from 1965 to 1991.

The data show that there has been an overall increase in real terms in appropriations to CSIRO. Until 1974 the increases were gradual but substantial, rising by 68 per cent in nine years. Between 1974 and 1980 funding stabilised, increasing by only 4 per cent. In 1980 funding increased in real terms by 16 per cent in one year. This increase is due to two administrative decisions. Firstly, in 1978, acting upon the recommendations of the Independent Committee of Inquiry into CSIRO, the government decided that CSIRO funding should continue to be through budgetary appropriation and that the Organisation should avoid over-reliance on Rural Industry Research Funds for the generation of revenue. Consequently, research funds, which had hitherto been allocated to other agencies who re-allocated them to CSIRO, were now to be paid by direct appropriation. In this way, for example, money from the Department of Defence's Materials Research Laboratories; funding for

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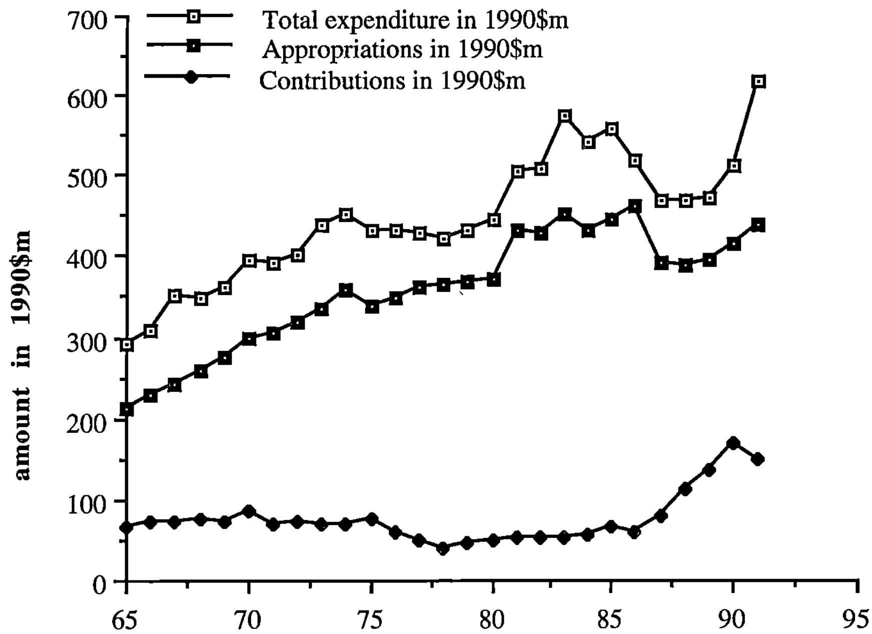
[62] Gresford, *The Organisation of Science Policy in Australia,* p. 11.

fisheries research and 60 per cent of the Wool Research Trust Account were transferred to CSIRO's direct appropriation.[63]

Figure 5.11: CSIRO, expenditure, appropriations and external funding, 1965-1991



Data source: CSIRO, *Annual Reports,* 1965-1991.[64]

Secondly, in 1981-82 the Fraser government implemented another recommendation of the Independent Inquiry that CSIRO should operate under a system of global budgeting in which: 'the government approves a total level of activity for the Organization and the Executive is free to allocate resources to objectives within that level'.[65] Direct appropriations were increased by 14 per cent in the 1981-82 Budget to enable CSIRO to cope with the new accounting and management requirements.

3.2.b Increasing accountability

These changes in financial and accounting procedures for CSIRO mark the beginning of the end of the organisational maintenance phase of the allocation of resources to the Organisation. The Organisation now had to meet all increases in costs from a single budget rather than simply passing them on to be met by the government in the form of

63 CSIRO *Thirty Second Annual Report 1979-80,* Parl. Paper 95, Canberra, 1981, p. 77.

64 The way in which expenditure, appropriations and contributions have been reported in the *Annual Reports* has changed over the period. Total expenditure data is taken from statements of Consolidated Funds. Appropriations were traditionally listed as 'Treasury Contributions'. Contributions from 1968-1986 are taken from the first table in each Financial Statement. Contributions include funds from the research trust funds which also include a government component.

65 CSIRO, *Thirty Fourth Annual Report 1981-82,* Parl. Paper 397, Canberra, 1982. p. 129.

increased appropriations for the following year. In the mid-1970s Fraser had continued the tradition of allowing scientists to decide the internal allocation of resources within the Organisation, and the above changes continued that policy.

At the same time considerable questioning of the role of CSIRO was occurring through such forums as the Royal Commission on Australian Government Administration; the Independent Committee of Inquiry into CSIRO in 1977, and the first ASTEC Report on Science and Technology in Australia in 1978. In the 1980s the Hawke government has had a very different concept of CSIRO's role and the allocation of resources to the Organisation reflects the political will to make the scientific activity undertaken within the Organisation more closely follow the needs of economic production across all industrial sectors.

Between 1984 (the first Budget totally controlled by an ALP government) and 1990 appropriations to CSIRO fell by 4 per cent. There were three years in the 1980s when, for the first time since the Organisation was in its infancy in the Depression, the government actually reduced the level of funding to CSIRO. The first (5 per cent) occurred in 1984-85 and was explained by Jones as due partly to the fact that government needed to assess its resource priorities in terms of an early general election (and that scientists are not effective political lobbyists); partly by the fact that certain functions such as the Landsat activity had been transferred to other agencies, and partly by the fact that the research and development phase of the aircraft landing system, Interscan, was complete.[66]

From the above discussion it is evident that considerable changes have taken place in the control of resource allocation to CSIRO in the 1980s. These changes have been concerned with forcing researchers in CSIRO to make their research more relevant to the needs of industry. CSIRO scientists have traditionally been allowed considerable autonomy and looseness of financial accountability in the internal allocation of resources to research projects. Government is increasingly exerting centralised control over the organisation of research through parliamentary scrutiny of accounting practices, and is expecting the Organisation to tighten internal control over its divisions.

3.2.c External fund generation and distribution

Between 1986 and 1988 appropriations for CSIRO were cut by 16 per cent in real terms. It was at this time that the government-induced organisational reforms took place: '...to align its [CSIRO's] structural elements with Australia's major economic and social activities'.[67] The financial means of achieving this realignment was a reduction in appropriation funds and a concommittant exhortation through ministerial guidelines to the Organisation for more reliance on outside sponsorship. The

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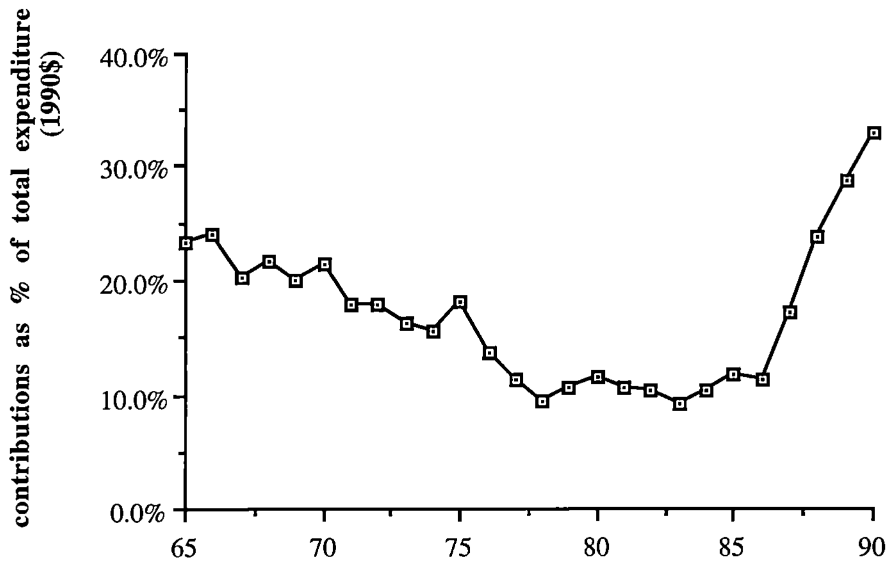
66 Jones, 'The 1984 Science and Technology Budget', pp. 245-248.
67 CSIRO, *Annual Report 1987-88,* Parl. Paper 37, Canberra, 1989, p. 46.

government's objective was for CSIRO to achieve external funding at the level of 30 per cent of total revenue. Figure 5.12 shows the level of contributions to CSIRO between 1965 and 1990.

Figure 5.12: CSIRO, external funds (contributions) as a percentage of total expenditure, 1965-1990, in 1990 $



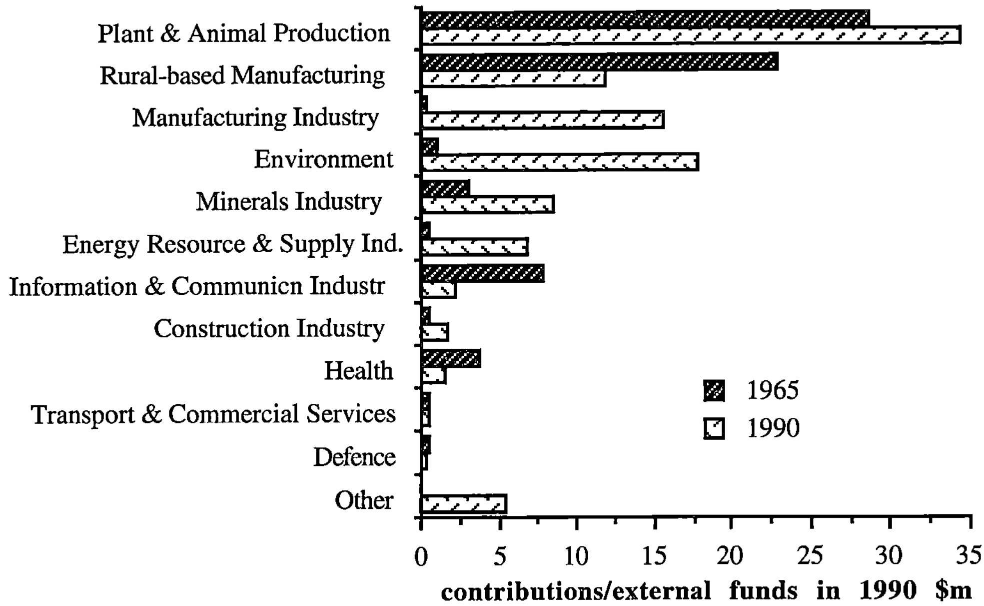
Data source: CSIRO, *Annual Reports,* 1965-1991.

The figure shows that external funding has always contributed a considerable proportion of CSIRO funds. In 1966 the level reached 24 per cent but declined gradually to a low of 9 per cent in 1983. Between 1977 and 1986 such contributions had hovered between 9 and 12 per cent of total expenditure, with a low point of 9 per cent in 1983. The change since 1986 has been dramatic. After the restructuring and redefinition of CSIRO's role in 1986, contributions became known as 'external funding' and increased from 11 per cent in 1986 to 33 per cent in 1990. As explained below, not all of this funding is from private sources and therefore cannot be interpreted as coming direct from industry. Nevertheless the increase has been substantial.

Of equal importance to the govenment's objectives for CSIRO is the use to which the sponsored research is put. Figure 5.13 shows the distribution of external funds for 1965 and 1990 by socio-economic objective.[68]

[68] As the 1965 contributions have been sorted into 1990 categories by the author it is unlikely that there is a perfect comparison.

Figure 5.13: CSIRO the distribution of external funds by socio-economic objective, 1965-90



Data source: CSIRO, *CSIRO Research 1990-91: Directory of CSIRO Research Programs,* CSIRO, Canberra, 1991, pp. x-xii.
CSIRO, *Eighteenth Annual Report of the Commonwealth Scientific and Industrial Research Organisation for the Year 1965-66,* pp. 207-233.

The most striking feature is that in 1990, as in 1965, the major proportion of external funds were for research connected with rural production. Nevertheless, the figure also shows that there have been some marked changes in the classification of contributions according to socio-economic objective. The greatest change has occurred in the manufacturing and environment categories. Manufacturing industry accounts for the largest category change since 1965. The environment category in 1990 included research into production-based environmental issues.[69]

There is some controversy over the Commonwealth government's use of the term 'external funding'. The funds listed as contributions and external funds in CSIRO's *Annual Reports* include funds from the private sector and funds transferred from other government agencies, both Commonwealth and State. Until 1969 the amount and name of each contributor was listed in the *Annual Report,* and private sector contributions could be distinguished from public sector transfers. Since 1970 this has not been possible. The situation is compounded by the use of funds from research trust accounts which include private and public funds. It becomes very hard to separate the two and therefore to ascertain exactly how much research work undertaken by CSIRO is being produced for commercial enterprises.

69 CSIRO, *CSIRO Research 1990-91: Directory of CSIRO Research Programs*, CSIRO, Canberra, 1991, pp. x-xii.

The issue of external funding for CSIRO is one which has provoked close parliamentary scrutiny. The situation was investigated by the Australian National Audit Office (ANAO) in 1991, and by the Joint Committee of Public Accounts in 1992. The ANAO found that CSIRO's management practices did not allow a systematic evaluation of efficiency and productivity with regard to the generation and use of external funds.[70] For example, the information published by CSIRO is not detailed enough in terms of sources of external funds, or the way in which the funds are used, to allow an assessment of financial performance. The Report recommended that CSIRO should adopt reporting practices which allow explicit definitions of funding arrangements, and that such practices should be uniform throughout all divisions of the Organisation.[71]

The Joint Committee endorsed the findings of the Auditor-General and recommended that a follow-up audit should be undertaken in 1993-94 to examine how CSIRO had responded to the efficiency report. In addition the Committee recommended that CSIRO (and other government research agencies) should ensure that overhead costs are included for all contracted research projects, including those undertaken for government agencies.[72]

Nevertheless, the data demonstrate a definite shift in the patterns of external funding both in the increased amount of funding and in the use to which the research is directed. The increases indicate a sizeable increase in the amount of sponsored manufacturing industry research. An examination of the internal allocation of resources within CSIRO should indicate the extent to which there has been an accompanying shift to techno-economistic objectives for the Organisation's appropriation funds.

3.2.d The internal allocation of resources in CSIRO

Figure 5.14 compares the proportional distribution of financial resources within CSIRO for the years 1965 and 1990. The figures used represent the total expenditure of CSIRO including appropriations, earnings and external funds.[73]

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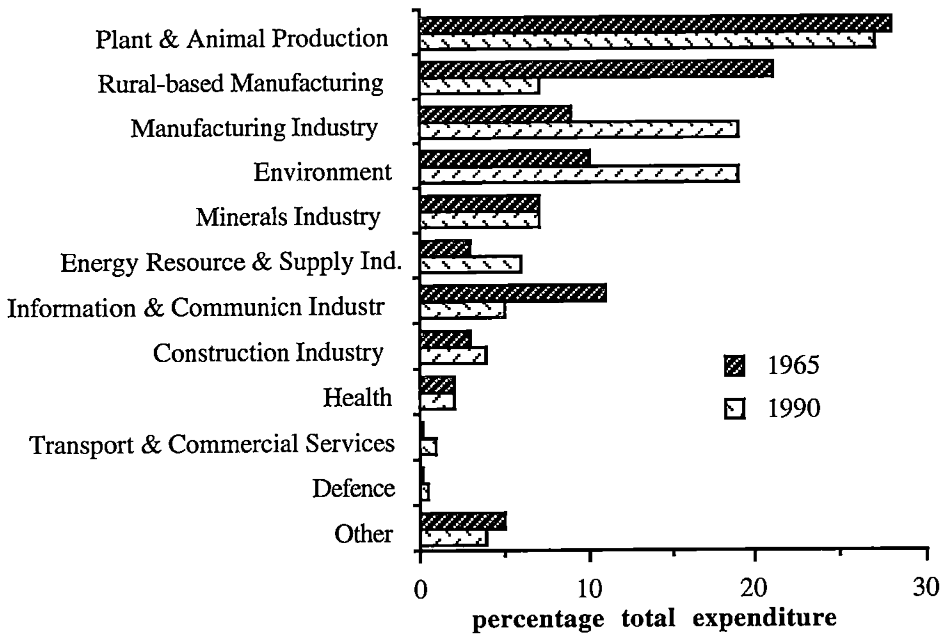
70 Australian National Audit Office, *Commonwealth Scientific and Industrial Research Organisation - External Funds Generation,* 2.3.61, p. 28; and 2.3.52, p. 27.

71 Ibid., 3.1.28, p. 34.

72 Australia, Joint Committee of Public Accounts, *Inquiry into Public Sector Research and Development*, p. 215-218.

73 The form in which such data has given has changed markedly in the 1980s. CSIRO Annual Reports now give only abbreviated financial data. Therefore in order to make the required comparison a spreadsheet was compiled of the data given in the *CSIRO Annual Report for 1965-66* and sorted according to the categories used in the CSIRO National Research Priorities Exercise 1990 which is the form in which the allocation of resources within CSIRO is presented in the *1990-91 Directory of CSIRO Research Programs.* This method is relatively simple but the figures obtained for 1965 cannot be considered as absolutely comparable with the figures for 1990 because of the difficulty of disaggregating scientific work done in any one organisational division or sub-division 25 years ago and re-categorising this work according to the final use to which the scientific knowledge was put. The *Environment* category shown on the graph is formed from the CSIRO National Research Priorities categories *Environment* and *Economic Development - Environmental Aspects.* Two other 1990 categories, *Transport Industries* and *Commercial*

Figure 5.14: CSIRO, internal allocation of resources 1965 and 1990



Data source: CSIRO, *CSIRO Research 1990-91: Directory of CSIRO Research Programs,* CSIRO, Canberra, 1991, pp. x-xii;
CSIRO, *Eighteenth Annual Report of the Commonwealth Scientific and Industrial Research Organisation for the Year 1965-66,* pp. 207-233.

The graph shows that the shift away from rural research to research for manufacturing industry and environmental affairs has been at the expense of rural-based manufacturing research. The component of research categorised as *Plant and Animal Production and Primary Products* for 1965 and 1990 has remained relatively stable at 28 per cent and 27 per cent respectively of research expenditure. Because there is no detailed breakdown of contributions/sponsorship for 1990 it is not possible to gauge the extent to which rural research expenditure in the various Institutes and Divisions is industry-oriented. However, the 1991 CSIRO publication *Australia's Science: Australia's Future* confirms that the level of expenditure on research categorised as being for rural-based manufacturing is substantially lower than expenditure for plant and animal production and for manufacturing industry.[74]

CSIRO research for manufacturing industry increased markedly from 1965 to 1990. In 1965 research for secondary industry accounted for only 10 per cent of CSIRO's total expenditure. This low level indicates the lack of interest in manufacturing as opposed to rural industry by CSIRO and the Menzies government. The strong electoral influence of rural interests and the political dependence of the

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Services have been grouped together because of the difficulties of including the tiny proportions involved on the same graph as the largest categories.

74 CSIRO, *Australia's Science: Australia's Future,* CSIRO Operational Plan 1991-92, CSIRO, Canberra, pp. 13; 29; 45; 67; 89 & 109.

Liberal Party on the Country Party meant that Country Party members occupied key positions in the executive core and subgovernment.[75] In 1990 the proportion of funding allocated to secondary industry research had risen to 19 per cent which is the same amount as that allocated by CSIRO to environmental research. However, given the Hawke government's continuous rhetoric about the need to increase the amount of scientific knowledge produced for and used by secondary industry, and the introduction of the tax concession which in 1990 equalled two thirds of CSIRO' appropriation revenue, this relatively low allocation indicates the extent to which CSIRO in 1990 is no longer trusted to be the Government's 'chosen principle instrument' for the distribution of funds for manufacturing research.

The smaller categories of research of Health and Defence are explained by the existence of the NH&MRC since 1937 and the separation of civil and military defence after the 'Red Scientist' political scandal in 1947. The low but consistent level of funding for mineral research in CSIRO has two causes. Firstly, the private minerals industry in Australia has always funded its own research, either in-house or at specialised institutes, at a level much higher than most Australian private industry.[76] Secondly, the Commonwealth government funds mineral research through the Bureau of Mineral Resources at a higher level ($53m in 1990) than the minerals research allocation of CSIRO ($34m in 1990).

The anomaly of a higher proportion of funding in 1965 for the Information and Communication Industries category reflects the greater emphasis in 1965 on Radiophysics and Research (mainly computing) Services. Whilst total CSIRO funding has almost doubled in real terms between 1965 and 1990 ($212m to $414m) the category *Information and Communications Industry,* which includes the above divisions, has decreased ($28m : $24m).[77] The lower allocation reflects the lower techno-economic utility of pure research in this area.

In the area of environmental research the Board of CSIRO has obviously decided that CSIRO has a major role. The types of research included in each of these

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[75] Fadden, McEwen, Page and Anthony were in control of the Treasury and Trade portfolios.
Crisp, 'Central Co-ordination of Commonwealth Policy-making:Roles and Dilemmas of the Prime Minister's Department', p. 39

[76] Professor Howard Worner, one time Research Director of CRA, holder of many academic and business positions in science and currently Professor of Microwave Physics at Wollongong University, indicated that, in his opinion the mining industry, both through the Australian Mining Research Association and through individual firms such as BHP, CRA and Western Mining Corporation, has been much more far-sighted in its integration of research and production than manufacturing industry.
Worner, Interview and Personal Correspondance, 3.11.89 & 6.11.89.

[77] It is unlikely that this is due to the compilation of the category in 1965. The sub-divisions included are: Radiophysics; Upper Atmosphere; Radio Research Board; Computing Research; Mathematical Statistics; Extramural Investigations; and Other Research Services. Of these only *Extramural Services* (4% of category) and the *Radio Research Board* (2% of category) are not included in the 1990 *Institute of Information Science and Engineering* .
CSIRO, *Australia's Science: Australia's Future,* CSIRO Operational Plan 1991-92, p. 7.

categories is given below.[78] Also listed are the areas of research from 1965 which are considered to be equivalent.

Table 5.4: CSIRO, environmental research categories 1965 and 1990

1965 (10%)	*1990 (19%)*
Fisheries and Oceanography	*Economic Development(9%)*
Land Research	Rural production
Tropical Pastures	Mineral production
Wildlife Research	Energy production
Soil Mechanics	Industrial production
Meteorological physics	Construction
	National Welfare (10%)
	Climate
	Atmosphere
	Oceans
	Land use
	Water resources
	Nature ecosystems
	Environment. impact & protection nec
	Other environment

Source: CSIRO *Eighteenth Annual Report,* Parl. Paper no. 316, 1964-65-66, pp. 207-231.
CSIRO, *Australia's Science: Australia's Future,* CSIRO Operational Plan 1991-92, p. 7.

The 1965 grouping of research areas correspond closely with the 1990 National Welfare Environment category (the Fisheries component is not separable in the 1965 Annual Report). However, examination of the titles from the list of publications from each Division in 1965 indicates that only in Wildlife Research was there a majority of articles not obviously connected with economic production. Awareness of the effect of human settlement and production on the Australian ecosystem has been a traditional concern of CSIRO. The allocation of 'new money' for environmental research through concern about the global environment has allowed this facet of CSIRO production of scientific knowledge to be emphasised. However, the 1991-92 internal allocation of resources shows that 'economic' aspects of the environment are being researched more than 'pure' environmental issues.[79]

3.2.e Summary of CSIRO resources

It would appear that CSIRO's basic role is still that of producer of scientific knowledge for rural industry, though with decreased emphasis on rural manufacturing. The second most important roles are in research for secondary industry and environmental research. Cultural research in such areas as radiophysics and the non-economic study of the environment is receiving a decreasing proportion of CSIRO funds. This reflects the view of the Hawke government that government-

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78 CSIRO, *CSIRO Research 1990-91,* p. xii.

79 The proportion of resources allocated to environmental research in 1991 fell slightly to 8.8% whereas projects researching economic aspects of the environment received 11.5% of total resources.
CSIRO, *Australia's Science: Australia's Future,* CSIRO Operational Plan 1991-92, p. 7.

funded research institutions should be instrumental in the restructuring of Australia's secondary industry. The requirement to generate external funds has also forced the Organisation to reassess its internal distribution of resources away from rural manufacturing and towards environmental and manufacturing research. The changes have been accompanied by an increased level of scrutiny of the use of funds within CSIRO by parliamentary agencies. The result of all the changes is that scientists's autonomy over the use of funds has been decreased.

3.3 Manufacturing industry

Australian manufacturing industries traditionally have the lowest level of research and development activity of all sectors of the scientific community. In 1961 Encel gave three reasons for this low level of scientific knowledge production in Australian manufacturing: Australia's industries were small-scale; there was a large proportion of overseas ownership; and a culture inherited from British firms of demanding tariff protection from government rather than investing in innovation.[80] This cultural inertia, combined with the political power of the Country Party to control ideas and resources for research, resulted in a low level of government intervention in the innovative policies of the manufacturing sector in the 1960s, and a low level of financial resources, both public and private, committed to manufacturing research. The growing awareness of the need for intervention, and the need for governments to overcome industrial inertia through techno-economistic programs of incentives for research, has resulted in an increased level of public and private research investment in 1990.

3.3.a Protection and innovation

In 1964-65 manufacturing industry policy was based primarily on the premises of import replacement and full employment to maintain consumption. The policy was underpinned by a strategy of tariff protection for local industries which in effect constituted a form of subsidy by consumers to domestic producers.[81] This protection allowed a diversification of industry at the expense of innovation and efficiency. Australian manufacturing firms were guaranteed domestic markets and did not have to compete with imports or compete in global markets for survival. A scientist who worked in manufacturing industry in the 1960s describes the situation thus:

> I had enormous frustrations in trying to persuade a company like AWA to adopt a relevant approach towards its innovative efforts. It was very happy to continue doing the things it had done for the last decade or two and did'nt really want to get involved in new developments. That was very frustrating for me because I was running a research laboratory and we kept on coming up with new developments that they did'nt want to know about.... You did'nt have to be innovative, you just had to make sure that that tariff wall stayed there because once you got 40% or 90% or 220% or whatever it was - and there were specific

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80 Encel, 'Financing Scientific Research in Australia', p. 265.
81 Ibid., p. 210 & 354.

as well as percentage tariffs such as 37c or 3/3d on every radio valve - so if you could make a valve for 1/4d you had over 200% protection.[82]

In 1965 the Committee of Economic Enquiry had calculated that tariff protection had given Australian producers the advantage of a 25-30 per cent general cost disability.[83] The Committee argued that manufacturing industry in Australia should begin to diversify away from pure import replacement by concentrating more on exports. To this end the dependence on imported technological know-how should be reduced by increasing investment in local research and development. Financial incentives for research and development in secondary industry should be provided by the Commonwealth government.[84] In 1967 the government's response to the Vernon Committee's Report was to introduce a system of grants to encourage industry to invest in the production of scientific knowledge as a means to greater wealth production and the replacement of imports.

3.3.b The Australian Industrial Research and Development Grants Scheme 1967-1976

In 1967 the Australian Industrial Research and Development Grants Scheme (AIRDGS) was established under the auspices of the Department of Trade and Industry. The government's objective was to increase the amount of research and development activity in the manufacturing and mining industries. Grants were calculated on the basis of the *increase* in research and development activity measured against the base year of 1965-66, and therefore were biased towards firms already undertaking research. Grants could be awarded for research undertaken outside the firm but only in laboratories in Australia. There were two categories of grant: *general grants* which gave 50 per cent of research and development increases up to $50,000 a year (ie a maximum grant of $25,000); and *selective grants* which consisted of up to 50 per cent of expenditure on increases in research and development above $25,000.[85]

<u>3.3.b.i Analysis of the AIRDS grants by class of industrial activity</u>

The first grants were made in 1967-68 and totalled $650,000 ($5m in 1990 values).[86] However, the first year of awards cannot be considered typical because of the haste with which the Board was established; the fact that the first financial year of funding included only ten months of operation, and the fact that explanatory notes helping

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82 Professor Richard E. Collins, Chairman ANSTO, member NERDDC, Department of Applied Physics, University of Sydney, Intervierw, 8.11.89.

83 Committee of Economic Enquiry, *Report 1965*, pp. 356-357.

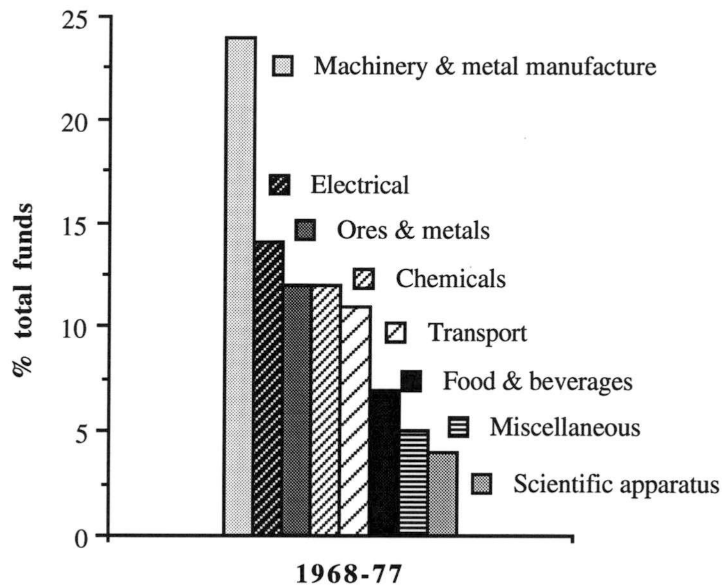
84 Ibid., p. 212.

85 Australian Industrial Research and Development Grants Board (AIRDGB), *First Annual Report 1967-68*, Parl. Paper 110, Canberra, 1968, p. 58.

86 Ibid., pp. 3-5.

companies to interpret the Act were not available until the second year of operation.[87, 88]

Figure 5.15: AIRDS grants 1968-77, selected grants by class of manufacture



Data source: Australian Industrial Research and Development Grants Board, *Annual Reports,* 1967-1978.

Figure 5.15 gives the proportions of AIRDGS grants awarded from 1968-77 by the eight most significant classes of manufacturing and mining activity.[89] Research and development activity, and therefore presumably science-based innovation, was highest in machinery and metal manufacture (24 per cent). Grants within this category of manufacturing were spread evenly across the subcategories with agricultural, construction and refrigeration equipment receiving the highest proportion of funds. A similar situation occurred with research and development grants for electrical manufactures with telephone, radio and television producers receiving the highest

87 Ibid., pp. 1-2; and
AIRDGB, *Annual Report 1968-69,* Parl. Paper 142, Canbera, 1968, p. 1.

88 In the Second Reading debate for the Industrial Research and Developments Grants Bill, Whitlam was doubtful about the Scheme's chances of effectiveness:

> The haste with which this proposal has been brought before Parliament indicates how little time has been available for carefully thinking out the implications and consulting the bodies which might be in a position to give advice. The original proposal was given in the last Budget by the Treasurer (Mr McMahon) in what was virtually an election promise. It has now been transferred to the jurisdiction of the Department of Trade and Industry. From our knowledge of what happens in the Department of Trade and Industry, we can have no confidence that the scheme will be administered in a disinterested fashion. The Department has no great knowledge or expertise in this field and it is likely that the administration of the scheme will be animated by the same spirit as the policy of protecting its industrial friends, regardless of the efficiency or of the benefit to the country as a whole.

Australia, House of Representatives 1967, *Debates,* vol. HR55, p. 2345.

89 The categories *food and beverages* and *machinery and metal manufactures* have been aggregated from four separate categories. No other categories of activity were so obviously similar in output. The graph uses figures aggregated over the life of the AIRDGS because yearly fluctuations in amounts awarded make longitudinal analysis on an annual basis meaningless.

amounts. However, the funding for some categories, such as ores and metals, and transport, were consistently dominated by research activity in particular areas such as copper production and road transport respectively. Often very large grants went to a single manufacturer. For example, in 1969 $0.47m of the $0.97m total awarded for new scientific knowledge in the transport area went to General Motors-Holden Pty. Ltd. Ten grants were over $100,000, representing 23 per cent of funds allocated to only 2 per cent of the 450 recipient companies.[90]

At the time of the Second Reading of the AIRD Bill in 1967, Whitlam had argued that not all research and development leads to economic growth therefore only selected areas of research should be funded, and small manufacturers should be favoured.[91] In 1974, under the Whitlam government, there was a marked change in direction for some of the hitherto largest beneficiaries of the scheme. Between 1968 and 1973 research and development grants for ores and metal production had consistently formed over 16 per cent of annual AIRDG funding. For the next four years the proportion barely reached 8 per cent. Transport production research and development suffered a similar fate with the proportion dropping from 17 per cent to 5 per cent. In 1974 only nine firms received grants over $100,000. This constituted 1 per cent of all firms and they received 8 per cent of the year's funds. The areas of production to benefit were chemical, machinery, electrical and electronic production.

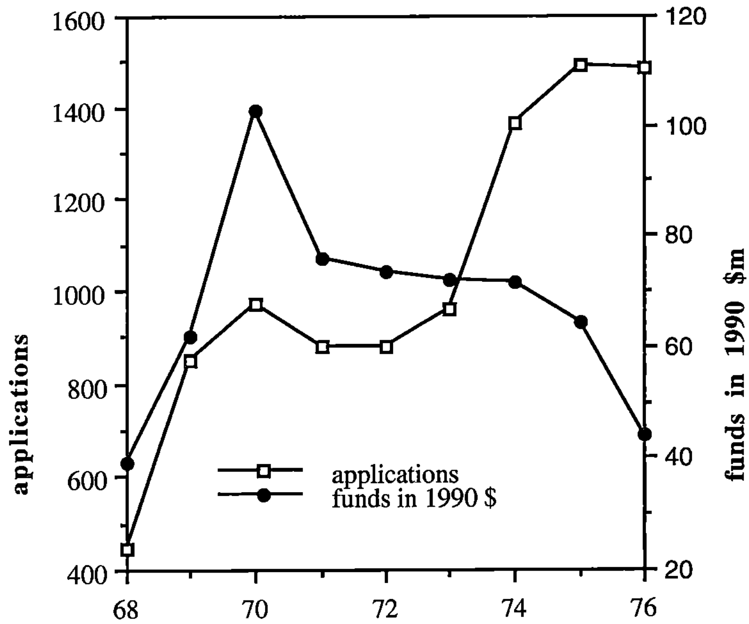
3.3.b.ii The availability of funds for AIRDS

By 1976 the scheme was in considerable trouble. Figure 5.16 illustrates the relationship between available funds and applicants for grants. From 1974 industry was increasingly asking for research and development money that had been cut back to 1967 levels in real terms. A new approach was needed and a new scheme was introduced by the Fraser government.

90 The ten were: General Motors-Holden's ($.47m); Amalgamated Wireless ($.27m); Imperial Chemical Industries ($.25m); The Broken Hill Proprietary ($.23m); Electrolytic Refining & Smelting ($.19m); Fibremakers ($.16m); Chrysler Australia ($.16m); Australian Iron and Steel ($.13m); Massey-Ferguson ($.11m); Radio Corporation ($.10m). AIRDGB, *Annual Report 1969-70,* Parl. Paper 126, Canberra, 1970, pp. 454-461.

91 Australia, House of Representatives 1967, *Debates,* vol. HR55, p. 2346.

Figure 5.16: AIRDS grants 1968-77, numbers of applicants and available funds in (1990$).



Data source: Australian Industrial Research and Development Grants Board, *Annual Reports,* 1967-1978.

3.3.c The Australian Research and Development Incentives Scheme (AIRDIS), 1976-86

The new scheme differed from the old in several ways: in the type of grants offered, in its structure, and in the criteria by which companies were selected for grants (structure and criteria will be discussed in chapter 6). The scheme survived until 1986 with numerous amendments but its inherent lack of flexibility and capacity to adapt to the needs of the Hawke government's science policy eventually led to its demise.

3.3.c.i Types of grant

The grants at the disposal of the Minister were of three types: commencement grants, project grants and public interest grants. Commencement grants allowed a company the lesser of an amount equal to 25 per cent of the eligible expenditure of the company in that grant year, or $25,000. They were intended to allow smaller companies the opportunity of establishing research and development activities and to that end companies which had already received either $125,000 in grants, or which had received grants over the previous eight years were excluded.

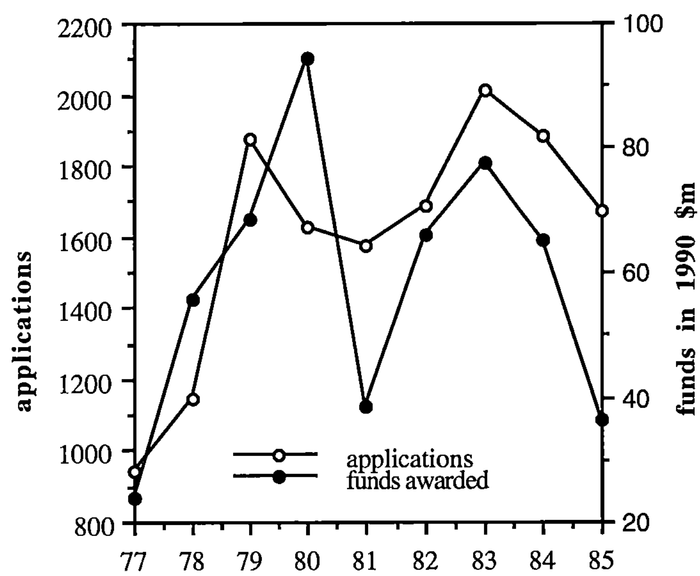
Project grants allowed a company up to 25 per cent of the amount that, in the Board's opinion, would be the company's expenditure on a project subsequent to the date of agreement. The maximum project grant was to be be $250,000 unless approved otherwise by the Minister. Each year the allocation for Project Grants would be 80% of the preceding year's allocation plus any amount that the Minister chose to allocate during the year.

Section 39 of the Act allowed the Minister to authorise the Board to make arrangements for the carrying out of specific projects of industrial research which the Minister determined to be in the public interest. These public interest grants were designed to encourage co-operation between government and industry on projects which otherwise would not be undertaken because of lack of short -term commercial viability but which were, in the long-term, of national interest.[92] Such grants were first awarded in 1978 and 77 had been awarded by the end of the scheme in 1986. The funding of such grants indicates the recognition by the Fraser government that intervention was as necessary in the relationship between research and manufacturing industry as it was in rural industry.

3.3.c.ii The availability of funds

Figure 5.17 illustrates the relationship between the availability of funds and the number of firms applying to the AIRDIS Board for both commencement and project grants.

Figure 5.17: AIRDIS grants 1977-86, numbers of applicants and available funds (1990$).



Data source: Australian Industry Research and Development Grants Board, and Australian Industrial Research and Development Incentives Board, *Annual Report*, 1967-1986.

The graph shows that throughout the life of the scheme funds generally paralleled the rise and fall in applications except for the large cut in funding in 1981 when the 'razor gang' approach was used by Fraser to reduce the Budget deficit. In 1979-80 applications outstripped funds and in 1980-81 funds were increased to meet demand.

92 Australian Industrial Research and Development Incentives Board (AIRDIB), *Annual Report 1985-86*, Parl. Paper 130, Canberra, 1987, p.9.

In fact eventual demand fell below expected levels because 11 per cent of applications were judged as ineligible under the conditions of grants. Midway through the following (1981-82) financial year the appropriations already set for AIRDIS were reduced by withdrawal of warrant. Commencement grants were cut by 8 per cent; project grants by 34 per cent; and the funds for public interest research by 60 per cent. Such drastic cuts at such short notice demoralised a staff already pruned below its 1978 levels, and caused confusion in industries where prompt receipt of funds was necessary to maintain or begin complex research and development projects.[93] Coupled with changes in structure and grant processing which delayed the Board's first selection meeting for three months into the same financial year these uncertainties reduced the credibility of the scheme in industry. Knowledge of the scheme was not widespread and of those who applied for the incentives many were unaware that grants were awarded on a competitive basis believing that it was necessary only to satisfy the criteria to obtain a grant.[94]

3.3.c.iii The need for change and the Jones solution

In the late 1970s and early 1980s there was a succession of enquiries into incentives for industrial research and development, and a consequent restructuring of the AIRDIS scheme which widened the criteria of selection. The establishment of a technical committee with the capacity to advise on the potential market viability of new scientific industrial knowledge effectively gave the government the sanction of witholding grants from companies on the grounds of market competence as well as scientific competence.

With the change of government in 1983 the AIRDIS scheme, enlarged to cover the computer industry, was placed under the auspices of the new Department of Science. The membership of the Board was increased to include market specialists and scientists from the new biotechnology industry.[95] The Board advised the Minister that the present scheme was unlikely to be able to implement his new policy because the need to operate through the Department of Industry, Technology and Commerce, and the Public Service Board, constrained autonomy, and therefore flexibility and speed in the allocation of resources.[96] In 1986 a new incentive scheme was established under legislation designed after consultation with industry, research organisations, professional organisations and universities.[97]

93 AIRDIB, *Annual Report 1980-81,* Parl. Paper 113, Canberra, pp. iii, 5-7; & AIRDIB*Annual Report 1981-82,* Parl. Paper 88, Canberra, pp. iii, 3-5, 22-25.
94 Ibid, pp. 2 & 22.
95 Ibid., p. 60.
96 In 1984-5 the Department of Science was merged with the Department of Industry, Technology and Commerce.
AIRDIB, *Annual Report 1984-85,* Parl. Paper 431, Canberra, pp. iii-iv.
97 AIRDIB, *Annual Report 1983-84,* Parl. Paper 321, Canberra, p. iii.

3.3.d The GIRD scheme 1986-1990

The new scheme is entitled the Grants for Industry Research and Development (GIRD) scheme and consists of four major programs for government support of industrial research and development: a 150% Tax Concession, Discretionary Grants, Generic Technology Grants and the National Procurement Development Program.

3.3.d.i The 150 % tax concession

The concession allows companies to deduct 150 per cent of the cost of research and development either performed in-house or contracted to approved research organisations. The full concession is only allowable when expenditure is $50,000 or more. All contracted research is deducted at 150 per cent. In the 1991 Industry Statement the then Prime Minister Hawke confirmed that the concession, which had been under threat of removal several times since 1985, was to be a permanent fixture of the incentive system. By 1989 there were 2202 manufacturing companies registered as eligible for concessions and the revenue foregone by the government totalled $1056m since the scheme's inception.[98]

It is interesting to note that, in 1980-81, the then Minister for Science and Technology, David Thomson, included a short discussion of the tax concessions for research and development in the first Science and Technology Statement. He noted advice from the Commissioner for Taxes that in the financial year 1979-80 approximately $1million of revenue was foregone as research and development under Section 73A of the Income Tax Assessment Act and another $1m as accelerated depreciation of plant used for scientific activity. This was equivalent to $6.5m in 1990 terms and was estimated to be at the level of a 46 to 55 per cent concession. At the present tax concession of 150 per cent this would be the equivalent of $19.5m which indicates a much lower level of research and development activity by industry in 1979-80. The Commissioner advised the Minister for Science and Technology that to claim the tax foregone as a form of government expenditure on research and development would be against normal practice and be 'meaningless' since the tax foregone would be recouped in the long-term by the revenue on extra income which results from the innovation process.[99]

However, in the same year ASTEC advised the Prime Minister that the business community was overwhelmingly in favour of tax concessions as the major mechanism for research and develpment subsidy in Australia. The Council cited the AIRG, whose members perform 85 per cent of the privately-conducted research and development in Australia, giving the advantages of a tax concession scheme as:

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[98] Industry Resesarch &Development Board (IR&DB), *Annual Report 1991-92,* Parl. Paper 236, Canberra, 1992, pp. 96-97.

[99] Department of Science and Technology, *Science and Technology Statement 1980-81,* pp. 117-118. The Holt Government also rejected the tax concession as the form of subsidy for research and development to be used in the original AIRDG scheme in 1967.
Australia, House of Representatives 1967, *Debates,* vol. HR55, p. 2357.

- autonomy in deciding which research should be undertaken;
- speed in initiating and carrying our research projects;
- the plans for, and the results of the research can be kept secret;
- reduction in the bureaucracy for application and selection procedures.[100]

Despite ASTEC's enthusiatic endorsement of the tax concession mechanism it was not introduced by the Fraser government, and did not receive Cabinet approval in the Hawke government until 1985.

3.3.d.ii Discretionary Grants

Discretionary Grants are aimed at small firms beginning to undertake research and development but which do not have enough taxation liabilities to benefit from the tax concession. The grant covers 50 per cent of eligible expenditure in excess of $50,000. In 1990 67 firms were awarded grants totalling $14m. In the five years of the GIRD scheme 370 firms had received a total of $92m.[101] In 1991 the scheme was enlarged to include service industries and market research.

3.3.d.iii Generic Technology Grants

Generic Technology Grants are designed to support pre-competitive strategic R&D in particular new or emerging technologies which are designated by the Minister as being of fundamental significance for industry competitiveness in the 1990s but which are unlikely to develop if left to market forces alone.

Researchers working in industry, higher education and other research centres are eligible for generic technology grants. The share of project costs met by the grant is determined on a case-by-case basis. In most cases grants will only be awarded to public sector researchers who have definite arrangements with private sector backers. For example, in 1990 the University of Tasmania and Australian Newsprint Mills received a grant worth $318,000 for research into the bleaching of recycled newsprint.[102]

Figure 5.18 shows that the funds for generic technology have been evenly distributed to the originally specified areas - Communications Technology was declared a priority area in 1987 and Waste and Environment Management Technology was declared a priority area only in 1990. Overall, 615 companies have applied for grants and 25 per cent of these have been successful. The most competitive area is Information Technology where only 19 per cent of applicants have been successful compared with 44 per cent in Communications Technology. The least competitive

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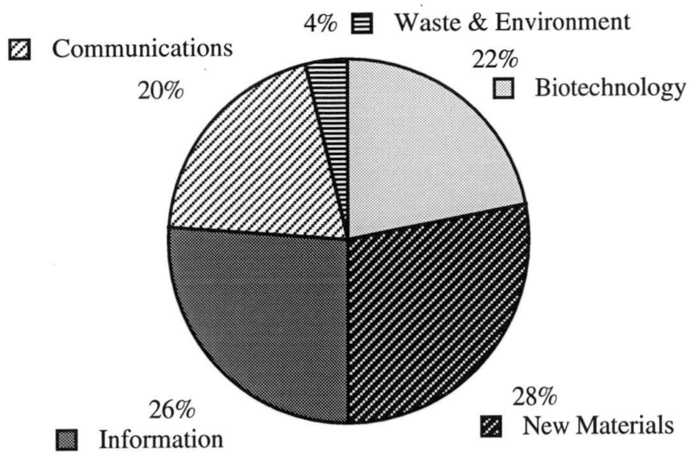
[100] ASTEC, *Industrial Research and Development; Proposals for Additional Incentives,* AGPS, Canberra, 1980, p. 33.

[101] The figures used in this section have been computed using data from each Annual Report. The way in which claims are received, processed and awarded for this type of scheme means that claims and awards are often backdated to the year in which the research activity was performed. Consequently, reported totals of applications, approvals and awards may vary. For example, the 1990-91 Annual Report states that 373 firms have received grants totalling $102 million. IR&DB, *Annual Report 1990-91,* p. 26.

[102] Ibid., p. 240.

area in 1990 was for New Materials Technology where 91 per cent of applicants received grants.

Figure 5.18: The distribution of generic technology grants by area of research, 1986-90



Data source: Industry Research and Development Board, *Annual Reports,* 1986-90.

3.3.d.iv National Procurement Development Program

The National Procurement Development Program was established in 1988 to fund projects which encourage government departments and agencies to seek Australian solutions for their forward procurement needs. In 1990 $6m was awarded under the program to such firms as Vision Systems in South Australia which, with the South Australian Police, developed and trialled a computerised management system for digital audio recording. The program, which in 1990 was included in the Industry Research and Development Act 1986, was due to end in 1990 but has been extended until 1994.[103]

3.3.e The proportional distribution of industrial research incentives from 1968-1990

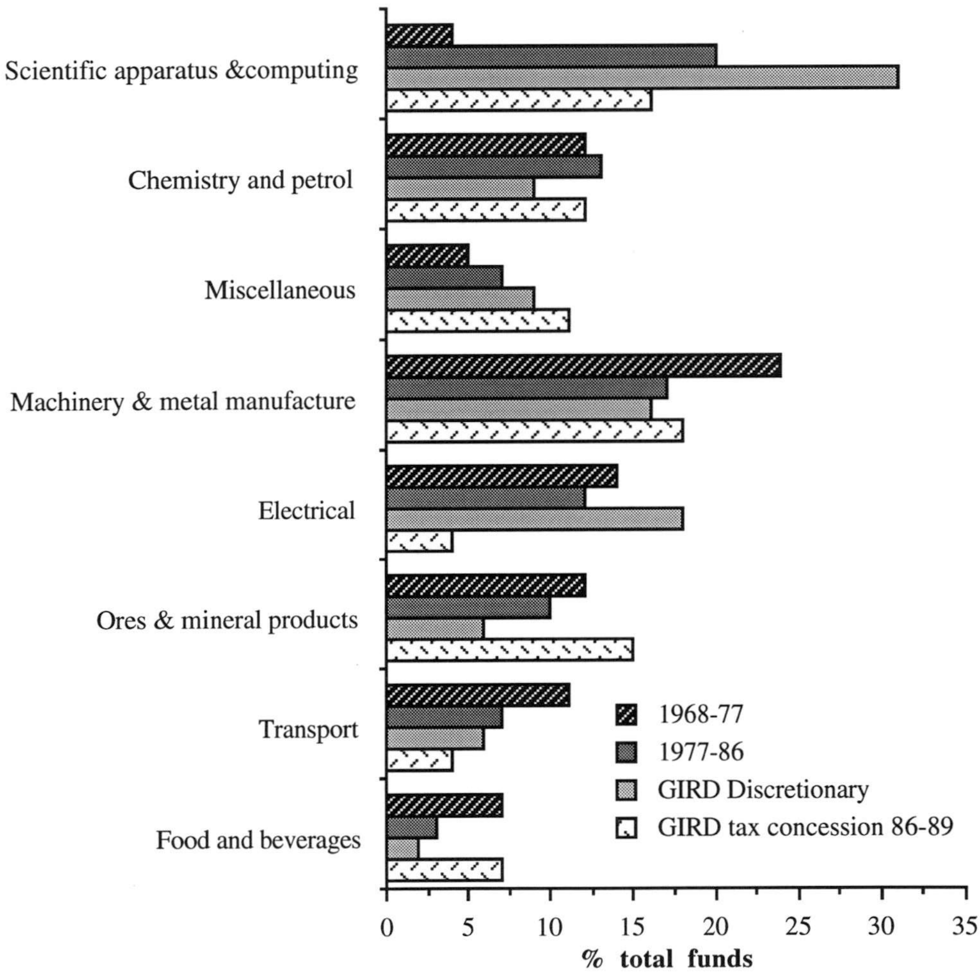
Figure 5.19 illustrates the pattern of change in the allocation of grants to different areas of manufacturing according to International Patents Classification (IPC) between 1968 and 1990.[104] The GIRD tax concesssion and discretionary grants have been used for

103 IR&DB, *Annual Report 1988-89,* Parl. Paper 23, Canberra, 1990, p. 57.

104 The data for the periods 1968-76 and 1977-86 used in Figure 5.16 are the same as those used in earlier figures. Data for discretionary grants in the GIRD scheme correspond to those for the earlier schemes. The tax concession data are presented in a slightly different way in the Annual Reports, in that the table in which the IPC data is given is sub-divided into *manufacturing* and *non-manufacturing* sections (see, for example, IR&DB, *Annual Report 1990-91,* Table A5.2, p. 140). However, unlike previous practice and for discretionary grants, data for the mining, construction and computer areas of manufacturing are given in the non-manufacturing section. This is because the tax data are prepared by the Tax Office which uses a different categorisation from DITAC which prepares the data on discretionary grants. For ease of comparison these data have been re-aggregated into the manufacturing data .

the period from 1986-90 because they are most similar in function to the project and commencement grants of AIRDIS, and the general and selective grants of the first AIRDG scheme. Some areas of manufacturing which receive incentives below five per cent of the total have been excluded in order to simplify the comparison. In analysing the graph it must be remembered that the data represent *percentages* of the amounts awarded and not the actual funds. The tax concession revenue foregone is roughly ten times the monies allocated as discretionary grants.

Figure 5.19: Comparison of AIRDS, AIRDIS and GIRD grants 1968-90



Data source: Australian Industry Research and Development Grants Board,
Australian Industrial Research and Development Incentives Board,
Industry Research and Development Board,
Annual Reports, 1967-1991.

The graph shows that the GIRD discretionary scheme favours companies in the scientific apparatus and computing area. Discretionary grants are intended for small, often new, firms which cannot take advantage of the tax concession. Research in this scheme is to some extent government-selected whereas research in the tax concession scheme is company-selected.[105] The scientific and computing area also has the

105 Obviously government outreach activity on research and development stimulation also has an effect on firms claiming research activity as a tax concession.

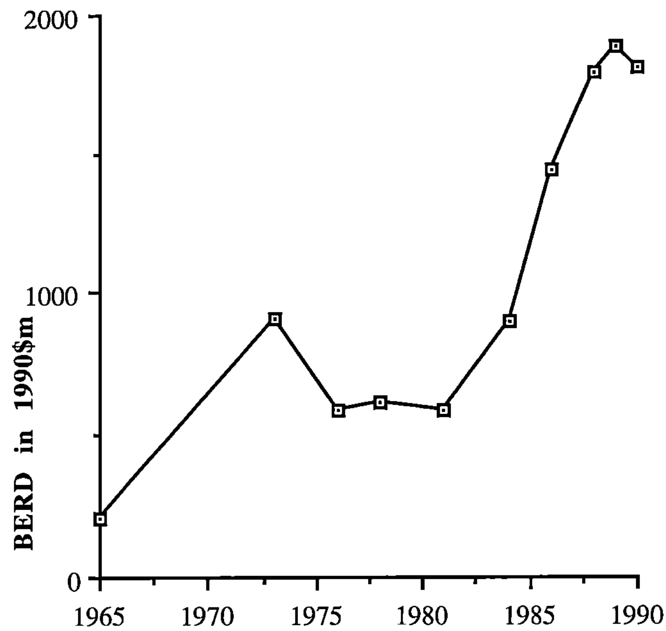
second highest amount of research and development tax concession and therefore is the area of manufacturing in Australia which not only has the most government approval but also conducts the most self-generated research. The higher proportions of tax concessions over discretionary grants in the chemistry, food and beverages, and miscellaneous areas indicate that it is the larger, more established firms which are doing more research. The mining (ores and mineral products) area claimed the largest amount of tax concession in 1989. Research activity in the electrical industry is occurring at a proportionally higher rate in smaller firms, whereas machinery and metal manufactures research is more evenly balanced between discretionary grants and tax concessions.

Over time the pattern of change is from the area of machinery and metal manufacture which accounted for 25 per cent of grants in 1965, to scientific apparatus and computing (remembering that computing only became eligible for AIRDIS grants in 1983). The minerals industry continues to invest in research, particularly through the tax concession scheme. Research in the chemical industries remains constant. The transport industry undertakes the least amount of research of the major categories in 1990.

3.3.f. The pattern of change in manufacturing research

The above discussion of government intervention into manufacturing research shows that the most significant changes in policy occurred when the Hawke government implemented its techno-economistic objectives for publicly funded research and development. Examination of the patterns of change in business expenditure on research and development (BERD) will indicate the effectiveness of these policies in encouraging manufacturers to commit private funds to science-based innovation. Between 1965 and 1990 BERD tripled from 13 per cent to 41 per cent.

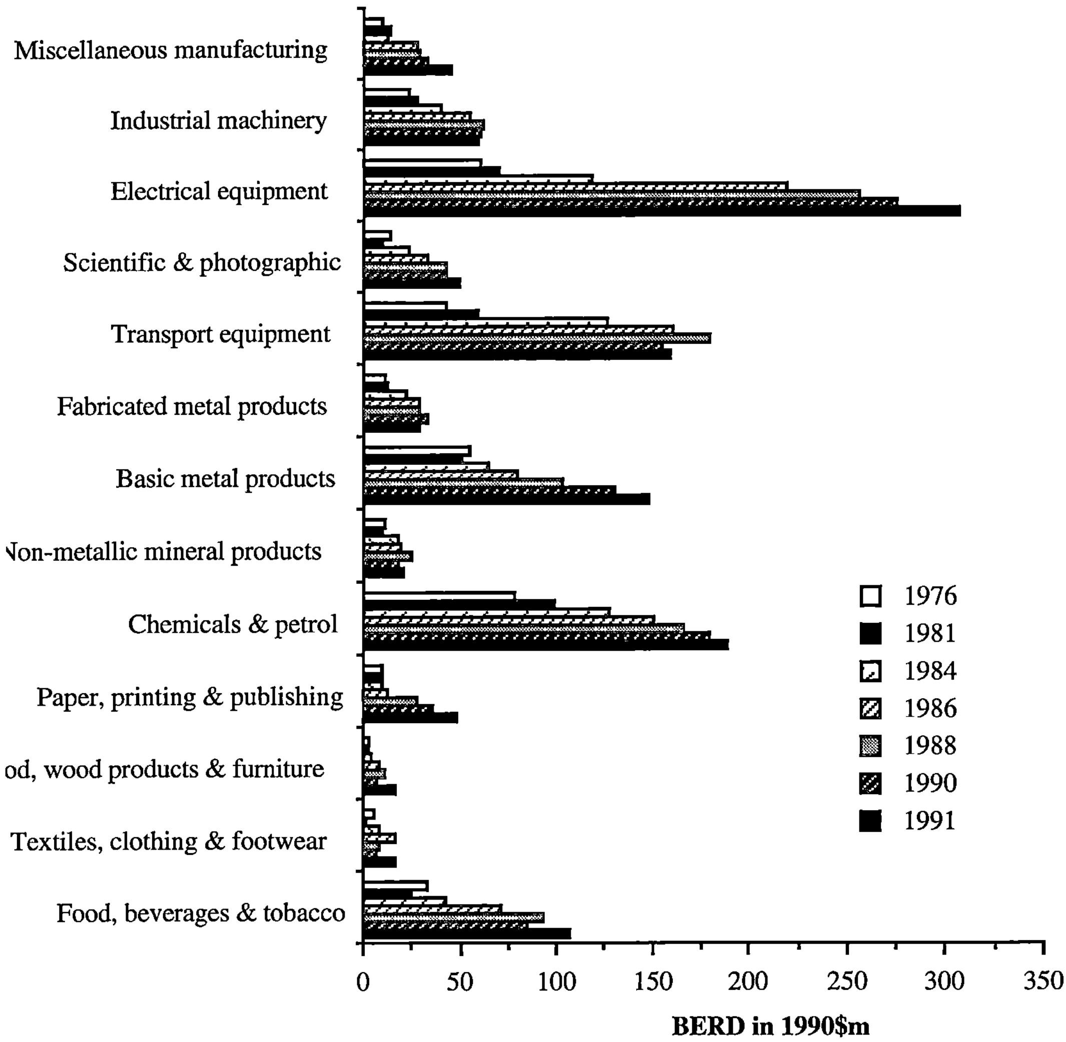
Figure 5.20: Australia, business expenditure on research and development, 1965-1990, in 1990$m



Data source: ABS Research and Experimental Development All Sector Summary, 1978-79, Cat No. 8112.0, 1985, p. 5.
Research and Experimental Development All Sector Summary, 1984-85, Cat No. 8112.0, 1987, p. 8.
Research and Experimental Development All Sector Summary, 1989-90, Cat No. 8112.0, 1985, p. 3.
Business Research and Experimental Development, 1978-79, Cat No. 8104.0, 1991, p. 2.
Stubbs, *Innovation and Research*, p. 29

Figure 5.20 shows that this dramatic increase ooccurred principally after 1983. It was not until 1985 that BERD regained the level in real terms of 1973. Since 1985 the amount has doubled indicating that the government's measures have been successful in encouraging the private sector to invest in research and development. Figure 5.21 shows the areas of manufacturing in which the response has been greatest. The figures for 1991 have been included to indicate the continuing trend.

Figure 5.21: Business expenditure on research and development by ASIC category, 1976-1990, in 1990$m



Data source:ABS *Research and Experimental Development All Sector Summary, 1978-79,* Cat No. 8112.0, 1985, p. 7;
Research and Experimental Development All Sector Summary, 1984-85, Cat No. 8112.0, 1987, p. 11.
Research and Experimental Development All Sector Summary, 1989-90, Cat No. 8112.0, 1985, p. 11.
Business Research and Experimental Development, 1988-89, Cat No. 8104.0, 1991, p. 3.
Research and Experimental Development Business Enterprises (Inter Year Survey)1991-92, Cat. no. 8114, 1993, p. 3.

The graph shows that the manufacturing area exhibiting the greatest increase in research and development expenditure has been that of electrical equipment which includes computer and other electronic equipment. The areas which have decreased levels of research and development spending are the more traditional areas of textiles, wood products, industrial machinery and fabricated metal products. One area of interest is that of scientific instruments in which growth has been fairly stagnant in the 1980s. The rise between 1990 and 1991 may be due to new technology arising from the increased emphasis on this area of research in higher education grants funding discussed in section 3.1.f above.

3.3.g Summary of manufacturing resources

In the area of manufacturing research both government and private expenditure has increased markedly in the period from 1965 to 1990. The increase was not uniform through time with the analysis indicating that in the 1970s the pace of innovation declined considerably. The major increases have occurred since 1985 in the areas targeted by the Hawke government as being essential to its techno-economistic science policy of orienting research and devlopment in Australia towards the radical restructuring of manifacturing production. There is some evidence that there is still a long way to go in this area.

In 1964-65 manufacturing industry in Australia employed 28 per cent of the workforce, produced 12.5 per cent of exports and accounted for 26 per cent of GDP. By 1990 manufacturing industry in Australia employed 16 per cent of the workforce, produced 18 per cent of exports and accounted for 17 per cent of GDP.[106] Apart from the fact that a greater proportion of exports are of manufactured goods, these figures encapsulate the manufacturing dilemma for Australia. Fewer people are engaged in producing a smaller proportion of the country's wealth. In terms of value-added to manufacturing as a percentage of GDP Australia has fallen from 14th place in the OECD with 25 per cent to 22nd in 1989 with 17 per cent; that is the fourth lowest with Norway, Greece and Denmark just above New Zealand, Canada and just below the United Kingdom.[107] Scientists still bemoan the lack of interest in science displayed by industry managers:

> ...of all the problems we face, the worst is the lack of understanding at the highest levels of the wealth-making ability of science....I have been truly shocked at the lack of expertise in our financial and legal sectors. They simply don't know how to make a buck out of science. They have no experience of it.[108]

It seems that, in some sectors of industry, twenty five years of increasing government intervention in the shape of incentives schemes for research and development in manufacturing industry still has not been sufficient to overcome industrial inertia and instil a market-driven ethos of innovation. Government can provide programs of support based on techno-economistic objectives of restructuring manufacturing industry; and can force public sector research organisations to align themselves with the needs of producers, but in the end it is the producers themselves who must transform the scientific knowledge into products and services. In this

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106 Foster & Stewart, *Australian Economic Statistics,* pp. 214-215.
ABS, *Australian Economic Indicators,* January 1992, pp. 24-25.
Bureau of Industry Economics, *Australian Industry Trends,* no. 18, May 1993, AGPS, Canberra, p. 46.

107 OECD, *Historical Statistics 1960-1989,* p. 63.

108 Professor David Neilson, School of Physics, University of NSW, 'Thinking small's our big chance', *Australian,* July 21 1992, p. 2.

respect manufacturing industry in Australia has always lagged behind rural industry in its capacity to generate and apply commercially new scientific knowledge.

3.4 Rural industry

Rural industry in Australia has had a long-term and productive relationship with the scientific community which has been articulated through State and Commonwealth governments. The political domination of rural interests, a tradition of relatively stable export markets and colonial constraints on encouraging Australian manufacturing industries have been responsible for science policies which have traditionally allowed scientists and producers considerable autonomy in the allocation of public resources provided for rural research.[109] Between 1965 and 1990 the relationship has continued to evolve as part of the increasing techno-economism in the relationship between government and the scientific community.

The pattern of funding for rural research has changed in size, scope and the mechanism of funding. In 1965 funds were allocated almost equally from the Commonwealth and States governments, through direct and special appropriation funding, to research projects in State laboratories and CSIRO. In 1990 more funds in real terms are allocated through a plurality of sources, including rural research corporations. This complexity means that there are difficulties in monitoring the changes: every major enquiry into rural research reiterates the difficulty of defining global funds. In 1989 the Bureau of Rural Resources reported that: '...data on finance allocated to rural R&D are not well documented at all'.[110] There are not many sources of data which are constant through time which can absolutely confirm or deny a trend. Consequently the following section uses a variety of sources to discern the trends.

3.4.a Budget funding for rural research

The importance to national economic well being of wool and other rural produce in 1965 is reflected in the proportion of research funds allocated to rural industry by the Commonwealth government. The Vernon Committee estimated that Australia spent three times as high a proportion of GNP on rural research as the USA.[111] There are no official estimates for rural research funds in 1965, but in 1968 it was estimated that, from all sources, the amount was $58m ($431m in 1990 values).[112] In 1986-87 the Department of Finance estimated that the amount spent on rural research from all sources was $545m ($684m in 1990 values).[113] This represents an increase in real

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[109] See chapter 2, footnote 36.

[110] G. Evans, C. Swinbank & R. T. Williams, 'An introduction to public sector resources allocated to research from the rural industries', *SCA Workshop on Research Priorities and Resource Allocation for Rural R&D*, AGPS, Canberra, 1989, pp. 8-14, p. 10.

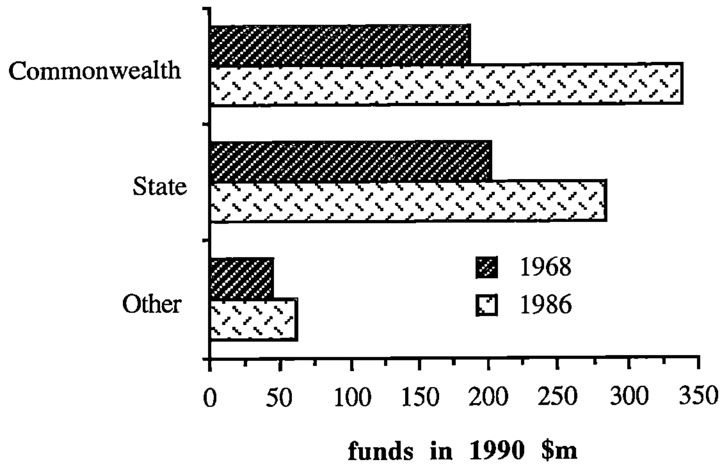
[111] Australia, Committee of Economic Enquiry, *Report 1965*, p. 424.

[112] Australia, *Project Score: Survey and Comparison of Research Expenditure*, Report 5, p. 13.

[113] The 1986 data do not include CSIRO funding allocated to rural research. It is not clear whether the 1968 data include CSIRO funds.
Bartos, 'Competing demands for Commonwealth funding', p. 55.

terms of 59 per cent. Figure 5.22 gives the estimated proportional distribution by source of funds.

Figure 5.22: Source of funds for rural research, 1968 and 1986 in 1990 $m



Data source: Project Score, *Survey and Comparison of Research Expenditure,* Report 5, 1973, p. 13; Stephen Bartos, 'Current Methods of Allocating Resources', p. 55.

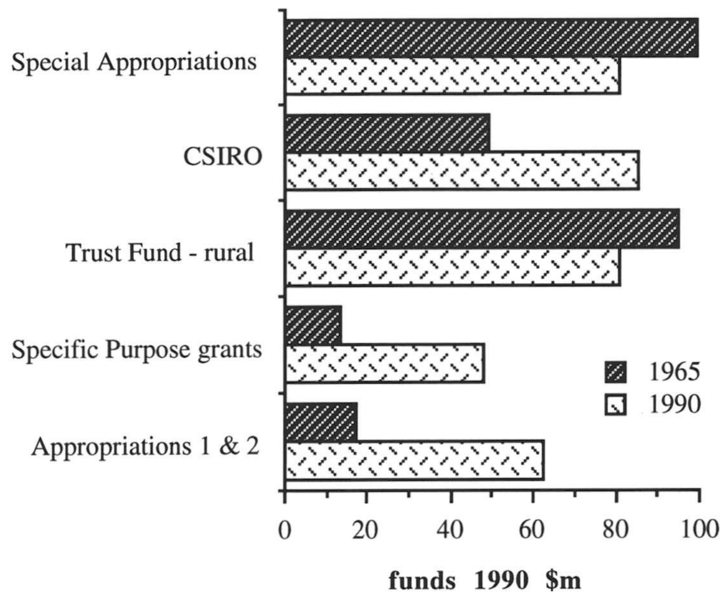
The graph shows that funds from all sources have increased in real value between 1968 and 1986. In 1968 the Commonwealth government contributed 41 per cent of the total: in 1986 this had increased to 49 per cent. However, it is difficult to ascertain exactly what proportion of State funds comes from the Commonwealth government in the form of Special Appropriations, Specific Purpose grants and program funds.

Figure 5.23 compares the way in which the proportions of selected funding for rural research, from Special Appropriations and other sources, have changed in real terms between 1965 and 1990. The disparity between the two years in the amounts appropriated under Appropriation Acts 1 and 2 is indicative of the growth of Comonwealth government support for rural research in the twenty five years. In 1965 only $2m ($16m in 1990 value) was appropriated for dairy, wheat, tobacco and barley research and for research advisory services.

In 1990 a total of $62m was necessary to support such activities as the Rural Industries Research, and Horticultural Research and Development Corporations; the Australian Bureau of Agricultural and Resource Economics and payments to CSIRO for screwworm research. In 1965 there was no Annual Report from which to gauge the Department's involvement in rural research (the first Annual Report of the Department of Primary Industry was tabled in 1980) and the half-dozen or so research funds in existence at the time seem to have enjoyed a very loose relationship to the Department. The Department of Primary Industries and Energy Annual Report 1990-

91 presents a complex array of financial statements reflecting the range of rural research activity carried on under the auspices of the Department.[114]

Figure 5.23: comparison of selected funding for rural research and development, 1965 and 1990 (1990 $)



Data source: Parliamentary Papers, 1964-65-66, vol. V, pp. 517-819; vol. VI, pp. 853-855; vol. VII, pp. 493-499; vol. VII, pp. 705-709; vol. VII, p. 719.
Budget Paper No. 2: The Commonwealth Public Account, 1990-91, pp. 40-50.
Budget Paper No. 4: Commonwealth Financial Relations with Other Levels of Government, 1990-91, Table 9, pp. 196-201.
CSIRO, *CSIRO Research 1990-91,* CSIRO, pp. x-xii;
CSIRO, *Eighteenth Annual Report of the Commonwealth Scientific and Industrial Research Organisation for the Year 1965-66*, pp. 207-233.

The use of funds by CSIRO shows the same pattern. The figures used here are the appropriation funds only because CSIRO has more control over the use of these funds than over external funds (or 'contributions' in traditional parlance) and they are therefore a more accurate indicator of the Organisation's objectives. In both years rural research accounted for 26 per cent of appropriations funds.[115] In 1965 this amount was $49m in 1990 values. In 1990 $86m was allocated to rural research, indicating that more money is internally allocated to rural research in CSIRO in 1990 than in 1965. In 1965, 88 per cent of contributions to CSIRO were for rural research and 37 per cent of the research designated above as rural was funded by contributions.[116] In 1990 34 per cent of all sponsored research activity in CSIRO was

[114] Department of Primary Industries and Energy, *Annual Report 1990-91,* AGPS, Canberra, 1991, pp. 326-395.

[115] The CSIRO data used for the graph is that designated in the two Plant and Animal Production and Primary Products categories in 1990 ($85.5m), and the Animal Research Laboratories, Plant Industry, Entomology and Horticulture and Irrigation categories for 1965 ($49m in 1990 values). CSIRO, CSIRO Research 1990-91: Directory of CSIRO Research Programs, CSIRO, pp. x-xii; CSIRO, *Eighteenth Annual Report*, pp. 207-233.

[116] In 1965 68 per cent of all contributions to CSIRO came from the Wool Research Trust Fund the majority of which would be Commonwealth Government contributions.

rural and 25 per cent of all rural research was sponsored. This would suggest that in 1990 rural research in CSIRO is more dependent on appropriated funds than in 1965, and therefore more open to government direction of funds.

In 1965 Specific Purpose grants were used far less frequently than in later years. In that year payments to the States for rural research constituted 45 per cent of Specific Purpose grants for research and were concerned mainly with agricultural extension services. In 1990 only 15 per cent of Specific Purpose grants were for rural research but the amount ($47.8m) was nearly four times the 1965 equivalent allocation. Over $47m of this money was spent on Bovine Brucellosis and Tuberculosis eradication programs in the States.[117]

Allocations of funds for the rural industry research funds are made through Special Appropriations. In 1965 all research funds allocated by Special Appropriations were for rural research under the meat, dairy, wheat and wool research legislation. Such funds formed 15 per cent of total Commonwealth and State funding for rural research.[118] In 1990 Special Appropriations research funds included monies for coal, fishing, mining and energy research and the proportion for rural research had fallen to 26 per cent.[119] The lesser amount of money allocated in real terms in 1990 fits the government's policy of reducing certain allocations for rural research.

The Trust Fund is the only source from which funds for rural research have declined in real terms.[120] In 1965, 53 per cent of monies held in the Trust Fund for research were spent on rural research. In 1990 this proportion was 35 per cent. In 1990 values $95m was spent in 1965 and $81m in 1990. This fall is probably due to the decline in wool exports and consequent fall in producer and government levy contributions.

In addition to the above broad conduits for governmental support of rural research there are, in 1990, other less obvious pathways by which public monies are used to fund the production of scientific knowledge for use by rural producers. For example, 70 companies claim $15m in tax concessions for rural research. In the discretionary grants scheme $1.8m went to research concerned solely with agricultural production. Similarly, biotechnology research funded under the GIRD generic technology scheme is often intended for commercial use in rural production. In 1990-

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117 The data for the Specific Purpose allocation are classified according to the CSIRO categories so that the 26% of the 1990 appropriation which was spent on environmental research programs such as soil conservation which could be thought of as beneficial to rural industry has not been included.

118 Industries Assistance Commission, *Financing Rural Research*, p. 2.

119 One third of the $5.2 million appropriated under the Primary Industry and Energy Act 1989 was considered to be for rural research purposes.

120 The Trust Fund monies used here do not include $8.5m (1965 value) designated for the Specific Research Fund even though a large proportion of these funds would be used by CSIRO for rural research.

91 the scheme funded $3.5m-worth of biotechnology research, $2.5m of which could be applied in agriculture.[121]

3.4.b The rural research trust funds and research associations

Despite the fact that the rural research funds account for only eight per cent of total public funds for rural research, this mechanism is often discussed by science policy analysts because of the unique way in which the relationship between governments, producers and scientists is articulated within the funds.[122] The relationship has changed markedly in recent years because of the way in which the Hawke governments have forced producers to take more financial responsibility for the research sponsored through the funds. It is worth examining the development of the relationship because it is a model of resource allocation which is repeatedly advocated for the manufacturing sector.

In 1965 there were four statutory rural research trust funds under the following legislation:

Dairy Produce Research Act 1958-65;
Wheat Research Act 1957;
Wool Industry Research Act 1962-64;
Meat Research Act 1960-65 (formerly the Cattle and Beef Research Act).

Other funds included those for tobacco, honey and dried fruits which at that stage did not have a fund specifically for research.[123] In general, the rural research funds operated in the following way:

1) a compulsory levy was paid by the producer through the taxation authority to the Consolidated Revenue Fund and thence under Special Appropriation to the relevant trust account;

2) an equivalent or negotiated amount was paid by the Commonwealth government under Special Appropriation into the trust account;

3) funds for approved projects were awarded to State departments, CSIRO, universities, agricultural colleges or other research agencies.[124]

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121 Industry Research and Development Board, *Annual Report 1990-91,* pp. 139-140; 21-213, & 223.

122 The Industries Assistance Commission described the funds as: '... a unique system of resource allocation and priority determination which provides for a degree of accountability equivalent to that recommended in the Rothschild Report'.
Industries Assistance Commission, *Financing Rural Research,* p. 47.

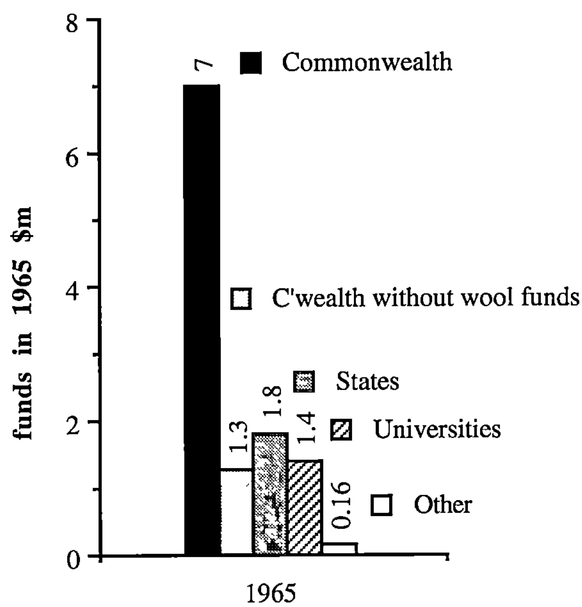
123 The government also funded, through CSIRO, private research associations. In 1965 CSIRO supported research in four such research associations, one of which, the Wine Research Institute, received $15,000 in grants. The Institute was established in 1955 out of the Oenological Investigations Section of CSIRO from funds raised by an excise on fortified spirits. The Institute receives equal funds annually from CSIRO and the Australian Wine Board. The others in 1965 were the Bread Research Institute; the Coal Research Institute and the Australian Leather Research Institute. In 1967 The Sugar Research Institute at Mackay was also recognised by CSIRO as a research association and received annual grants of $200,000. It had been in existence since 1949 as Sugar Research Ltd., formed by a group of 26 sugar mills.
CSIRO, *Eighteenth Annual Report 1965-66,* p. 218.

124 Australia, *Report of the Auditor-General,* 1965-66, pp. 671-691.

Each fund was administered by an industry research council consisting of members from universities, CSIRO, the Commonwealth Department of Primary Industry, representatives from producers' associations and a representative from each of the State industry research committees. The State committees in turn had representatives of producers, State departments of agriculture, universities and specialist rural institutions. Expenditures on wool research were made, with Ministerial approval, by the Australian Wool Board on the recommendations of research advisory committees.

Proposals for projects arose in two ways. Either a committee contacted research organisations advertising the availability of funds; or the committee decided on research priority areas and advertised for tenders.[125] Research was spread across a range of research organisations in all sectors. The exception was the Wool Research Trust Fund, which allocated the bulk of its funds (81 per cent in 1965) to CSIRO. Figure 5.24 illustrates the effect that wool research funds had on the total distribution of resources from the rural Trust Funds.

Figure 5.24: Research organisation sectors receiving rural research trust fund monies, 1965



Data source: *Report of the Auditor-General,* 1965-66, Parl. Papers vol. VI, 1964-65-66, pp. 671-691.

The majority of wool research funded by the industry was carried out by CSIRO. This situation continued until the mid 1980s despite continuing warnings about the over-dependence of certain CSIRO divisions on the fluctuating value of wool; the potential lack of fresh perspective on industry problems, and the lack of support given to scientists in the universities.[126]

125 Industries Assistance Commission, *Fininacing Rural Research,* p. 47.

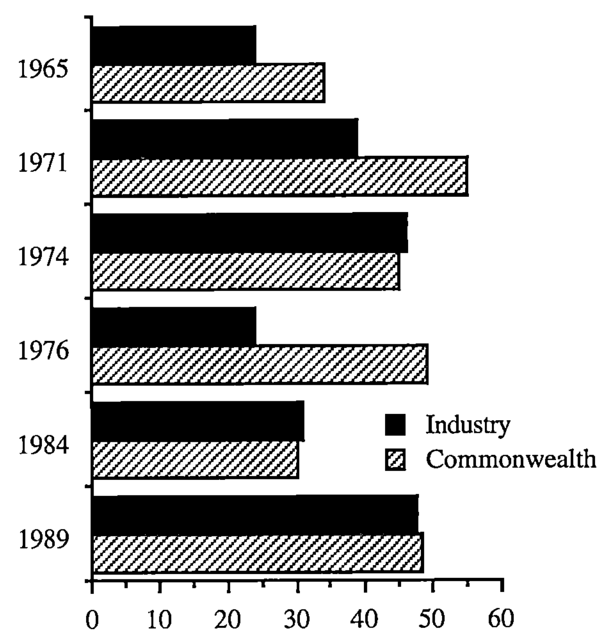
126 See the IAC Report *Financing Rural Research,* chapter 7. The Australian Wool Corporation was obviously sensitive about the issue. Unlike other Rural Research Trust Funds' Annual Reports

The amount of funds at the disposal of the Trust Funds, although representing only 15 per cent of total spending on rural research, is at the core of the fact that, in the 1960s and 1970s, the trust fund advisory committees influenced to a large degree the direction of rural research in Australia by providing extra research funds. The large research organisations in the Commonwealth, State and university sectors of the scientific community had to bear the escalating costs of scientists' salaries, and since most scientists were in tenured positions, the research institutions were constrained in their operational flexibility.[127]

3.4.c The transition in rural research funding

Figure 5.25 shows the pattern of contributions to the four largest and longest-established rural research funds (dairy, meat wheat and wool) between 1965 and 1989.[128] The most apparent feature of the graph is the way in which Commonwealth government contributions to the funds exceed industry contributions in years in which conservative political parties were in power. In 1974, 1984 and 1989, when the ALP is in government, the contributions were more evenly balanced.

Figure 5.25 The four major rural research trust funds, contributions by government and industry, 1965-1989 in 1990 $m



Data source: Auditor-General's Reports, 1965-76;
Department of Primary Industry Annual Reports, 1980-89;
Australian Meat Industry Research Corporation, *Annual Report 1990-91.*

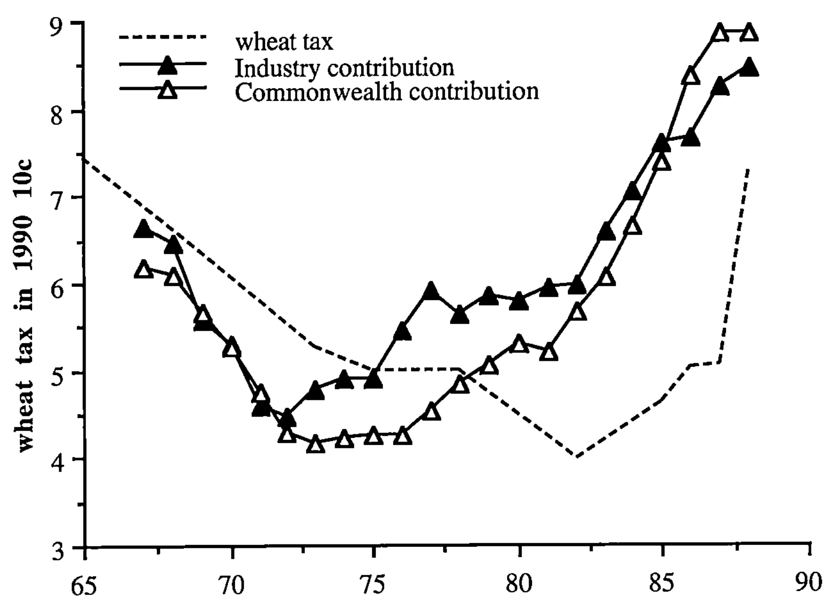
details of payments to CSIRO were separated from details of payments to other research institutions. In later reports the details were sometimes given in tables on separate pages from the others, and sometimes buried in the text.

127 F. G. Jarret & R. K. Lindner, 'Rural Research in Australia', in *Agriculture in the Australian Economy,* ed. D B Williams, Sydney University Press, Sydney, 1982, pp. 83-105, p. 92.

128 By 1990 most of the funds were incorporated. The meat industry research fund was one of the first of the funds to be incorporated in 1985. The 1989 data for meat industry research is therefore that of the Australian Meat Industry Research Corporation.

An examination in greater detail of one particular fund modifies this interpretation somewhat. The level of tax which producers pay is an indicator of a government's policy regarding the activity funded by the tax. Raising the tax commits a higher allocation of public funds to that activity, but also increases industry's share of the costs. Figure 5.26 illustrates the relationship between industry contributions and Commonwealth contributions to the Wheat Industry Research Trust Fund, and the real value of wheat tax paid. The wheat industry is used as an example because the Commonwealth government and industry contributions have been evenly matched over the thirty years of operation. The Wheat Research Trust Account receives 100 per cent of the tax raised. All amounts have been converted into 1990 dollars and cents.[129]

Figure 5.26: Wheat Research Trust Account, Commonwealth and industry contributions in 1990 $ (5 year moving average), and tax per tonne in 1990 ¢, 1965-89



Data source: Wheat Industry Research Act 1957, Annual Reports 1965-1989.

The graphs show a close fit between Commonwealth contributions and industry contributions as is to be expected when both contributions are tied to production levels. In 1965 the wheat tax was 0.25 cents per bushel in current values (9 cents per tonne). In 1973 this was raised to 11 cents per tonne current value and the tax rate gradually rose to reach 65 cents per tonne in 1989.[130]

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129 For the fund contributions the data have been smoothed to allow the trends to show through annual fluctuations. The tax data are not smoothed but are represented in amounts of 10c to allow comparison on one graph. The first datum for tax in 1965 is shown as 7.5, and should be read as 75 cents.

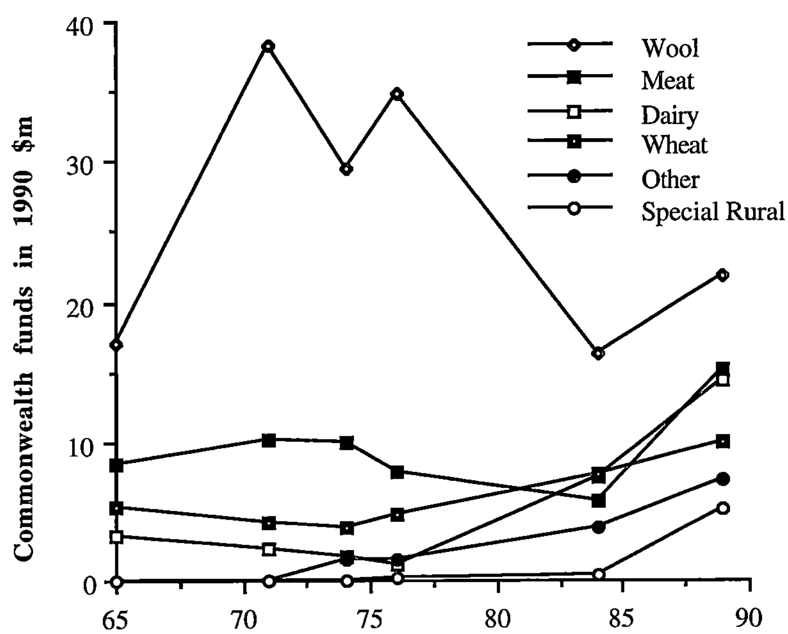
130 Wheat Research Act 1957, *Annual Report 1988-89,*AGPS, Canberra, 1990, p. 23.

The dotted line on the graph, however, shows that the real value of the tax rate followed a different pattern. From 1965 to 1973 the real tax rate value fell by 70 per cent. Between 1973 and 1975 it continued to fall against a rising rate of production as indicated by the increasing level of industry contributions. The rate was stable in value from 1975 to 1978 and then fell sharply, again against a rising rate of production, and reached its lowest-ever real value in 1982. From 1983 the real tax rate has risen with the rate of production. This would seem to indicate that it was not until 1983 there was a dramatic change in policy about government contributions to wheat research. The Hawke government intended that the level of the wheat industry's commitment to research activities should rise if the government was to continue to invest public funds in wheat research.

3.4.d Rural industry research funding in 1990

The changes were not confined to the wheat industry. Figure 5.27 shows the pattern of Commonwealth contributions to the rural research trust funds since 1965. Data on the four major funds are individually plotted. 'Other' funds in such industries as chicken meat, barley, honey, oilseeds and cotton are added in to the data as the funds were opened. Special rural research funds have been allocated only since 1984.

Figure 5.27: Commonwealth contributions to rural research funds, 1965-89 (1990 $)



Data source: Auditor-General's Reports, 1965-76;
Trust Fund Annual Reports, 1976-90;
Science and Technology Budget Statement 1989.

The most significant aspect of the funding pattern is the outstanding commitment of successive Commonwealth governments to the support of wool research which for many years received twice the level of government contribution of other commodities.

The contributions for wool have been calculated on a value basis since 1964 and the pattern of contributions shows the fluctuating nature of the value of wool production. In 1985 the real value of the level of wool research funding was the same as in 1965. Contributions for the other commodities have been on a value basis only since 1985. The graph shows the way in which research funding for the dairy and meat industries, which were corporatised early, has increased at a much greater rate since 1985.

Also significant is the rate of increase in funding to the smaller funds and to special rural research. This indicates an increasing rate of production and value in line with the government's policy to decrease Australia's dependence on a narrow range of rural commodities. Contributions to all commodities except wheat and wool have at least doubled in real terms since 1984 which indicates that the rural industry research corporations have been a major mechanism for the Hawkė government's restructuring of the rural industry.[131]

The restructuring of the research funds and councils has changed the balance of control over the direction of research. Producers and researchers now have to share decision-making with commercial expertise, and to a more nominal extent, with the Minister. The structure which has been established is of eleven autonomous rural research and development corporations reporting directly to the Minister for Primary Industries and Energy. In addition there are five Research and Development Councils for smaller rural industries which come under the umbrella of the former Australian Special Rural Research Council, now re-constituted as the Rural Industries Research and Development Corporation (RIRDC). These Councils are legally required to present annual reports of their activities to the RIRDC before submission to the Minister, but in practice the RIRDC has so far allowed the Councils to report independently. The RIRDC also funds research into developing rural industries not eligible for other funding.[132]

Within the Department of Primary Industries and Energy a Rural Policy Division has been set up to oversee the corporations. The Bureau of Rural Resources operates at a technical level acting as an interlocuteur between scientific and policy communities. The Primary Industries and Energy Research Council advises the Ministers on the performance of the Rural Research and Development Corporations. Resource allocations are decided within the Department of Primary Industries and

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131 In August 1992 the Keating Government announced that the Commonwealth Government's contribution to the rural research corporations would be decreased. Instead of matching industry contributions up to 0.5 per cent of Gross Value of Production (GVP), the Government intended to allocate $1 for every $2 raised by an industry up to 0.25 per cent; $1 for every industry $1 between 0.25 and 0.5 per cent, and $1 for every $2 from there up to 0.75 per cent of GVP. The decrease is said to have been agreed to by the Expenditure Review Committee on the advice of the Department of Finance but against the wishes of the Minister for Primary Industries and Energy. The decreases were withdrawn after intense lobbying by the rural subgovernment. Tim Stevens, 'Cabinet slahes rural grants', *Weekend Australian,* August 1-2, 1992, p. 1.

132 Rural Industries Research and Development Corporation, *Annual Report 1990-91,* Parl. Paper 437, Canberra, 1991, p. 1.

Energy by the Minister on advice from the Department of Finance. The use of policy caps on expenditure for portfolios has meant that the responsibility for deciding the allocation of resources for rural research lies squarely with the Minister.[133]

3.4.e Summary of rural resources

The funding of rural research is a complex set of arrangements involving industry, public policy agencies in Commonwealth and State governments and the many institutions of the science system. The information analysed for this thesis indicates that the overall envelope of public resources allocated to rural research has increased slightly in real terms between 1965 and 1990. The Bureau of Rural Resources estimated that public sector funding for rural research increased by 108 per cent in real terms between 1979 and 1988. These changes reflect the changing objectives of governments for rural reseach, and the assertion of central control in the reallocation of resources to meet these objectives. The Hawke governments in particular have established new patterns of resource distribution. Corporatisation of the major rural research trust funds has passed greater financial responsibility to market forces. Resources are now allocated to research for smaller rural industries as restructuring of production attempts to compensate for falling prices in traditional markets. However, central control has taken the form of Commonwealth government monitoring of the use of rural research funds as declining markets demand greater efficiency. This has entailed the re-organisation of funding arrangements described above and the development of evaluation procedures which will be examined in chapter seven.

4. CONCLUSION

This chapter has examined the pattern of funding for research and development in four sectors of the science system between 1965 and 1990. The science system is funded through a multitude of mechanisms including direct appropriations, special appropriations, matching levy contributions, competitive grants, recurrent grants, tax concessions, intergovernmental transfers and private funds. It is therefore very difficult to obtain an absolute picture of change. There are several significant points which emerge from the above analysis.

Firstly, there has been an overall increase in real terms in the amount of public funds allocated to research. Estimates of total research and development funding are inherently difficult to obtain because of fragmented sources and destinations of the allocations. In 1965 an estimated $137m was spent by the Commonwealth government on research and development. This is the equivalent of $1136m in 1990 values. Using similar methods of calculation for this thesis the total obtained for 1990 is $2058m. In 1990 the estimated total in the*Science and Technology Budget Paper*

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133 Bartos, 'Competing demands for Commonwealth funding - the effect on rural research and development', in *SCA Workshop on Research Priorities and Resource Allocation for Rural R&D*, pp.47-56.

No.6 is $2422m, or over twice the amount in 1965 in real values. This amount, however, includes revenue foregone through the 150 per cent tax concession. In 1965 the 100 per cent tax concession allowed would not have been included in any formal estimate of research and development funds.

Secondly, research funding is spread more evenly between portfolios and research agencies. There has been a definite shift away from defence research and towards health research, and research undertaken in the higher education sector. The proportion of rural research funding remains high but the level of public funds allocated to research in the manufacturing sector demonstrates ALP governments' commitment to restructuring Australian economic production away from over-reliance on unprocessed rural commodities.

Thirdly, the traditional pattern of dependence on CSIRO to stimulate research of national economic benefit, has been replaced by a model of resource distribution based on superstructural and executive core monitoring of a plurality of research schemes. This control trend has occurred in all sectors. In higher education there has been a redistribution of resources away from recurrent grants to the competitive grants scheme. This has decreased the autonomy of significant actors in the individual institutions. The introduction of the Co-operative Research Centres under the control of the Chief Scientist in the superstructural subgovernment has further centralised power in the higher education science policy community away from the higher education subgovernment and its domination by academic scientists. In manufacturing research control of the tax concession has been shared jointly between the ATO and DITAC. In the rural research sector the establishment of the Primary Industry Rural Research Council to co-ordinate the allocation of portfolio resources to research, and the corporatisation of the trust funds has changed the balance of control away from researchers and towards government and market agencies.

Fourthly, the eventual adoption of a 150 per cent tax concession after twenty years of science policy advocacy indicates the government's determination to impose techno-economic objectives in the face of the failure of market mechanisms to stimulate the emergence of science-based industries. However, manufacturing industry is still loath to adopt the rural research model of levies distributed by market-oriented research corporations for pre-competitive research, claiming that such a system is not tenable given their greater dependence on the domestic.market. The joint funding by companies of generic research through the IR&D scheme, and through Co-operative Research Centres is a step in the direction of collective manufacturing research funding.

Fifthly, there is an increased awareness within the executive core and the attentive public of the need to monitor the use of public funds allocated to research and development. This chapter has shown that, in CSIRO, in the higher education sector, and presumably in the health research subsystem, the way scientists label their research creates a potential for the obfuscation of the micro-level objectives of scientists. This gap between political accountability and scientific jargon is recognised by Parliament which is demanding closer scrutiny of research allocations.[134]

Sixthly, there has been an increase in funding labelled 'environmental'. This is explicitly reported as such in CSIRO but inspection of the internal allocation of resources in 1965 reveals that similar research was undertaken twenty five years ago without being labelled 'environmental'.

Finally, there is a difference between the way in which funds are allocated to rural research, and to research in the higher education sector, from the way in which funds are allocated to non-rural research. The former process occurs through specific purpose and special appropriations: the latter through direct appropriations. This difference is historial in origin, occurring as Commonwealth governments assumed responsibility for areas of research formerly funded by the States. The question must be asked why some agencies such as CSIRO, ANSTO and the manufacturing industry research grants systems were brought under direct financial control, and why rural, health and higher education research have remained indirectly funded. It may simply be a case of administrative and legislative inertia. More likely is the perception that these areas of research are seen as of less importance to the radical techno-economistic objectives of Commonwealth governments for the science system.

It seems that in the areas in which Commonwealth governments want to keep close centralised control, as in CSIRO, ANSTO and grants for manufacturing research, such inertia can be overcome. However, in general all sectors are more closely observed. Public sector research organisations are increasingly funded according to government priorities rather than scientists' priorities. Grants to individual and institutional scientists are now awarded according to criteria based on the prioritisation of certain fields of research. Publicly-funded research organisations have been forced to raise a proportion of their revenue outside the public purse. Governments have increasingly used public funds to underwrite the production of scientific knowledge for the use of private economic production. In line with other allocations to government activities, funding for the production of scientific knowledge has become much more open to processes of accountability. The outcomes of the changes will be examined in the following three chapters.

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[134] These concerns are expressed by the Joint Committee on Public Accounts in its recommendations to rectify the poor management of research organisations, and to increase the role of the Bureau of Industry Economics, the Bureau of Rural Resources and the Australian Bureau of Agricultural and Resource Economics.
Australia, Joint Committee of Public Accounts, *Inquiry into Public Sector Research and Development*, paras. 9.26 & 9.36, pp. 169 & 171.

CHAPTER 6

RESTRUCTURING THE ORGANISATION OF RESEARCH

Chapter five revealed changing patterns in the control of the allocation of resources in the science policy community. In this and subsequent chapters other significant outputs of science policy are analysed. They are: the restructuring of the organisations of the production of scientific knowledge; the processes of prioritisation, selection and evaluation; the characteristics of the knowledge produced; and the way in which this is applied to societal needs. This chapter examines the way in which research organisations and funding mechanisms have been restructured by subgovernmental actors to achieve techno-economistic objectives. Chapter 7 discusses the way in which the evaluation techniques of research have been changed by similar objectives; and chapter 8 looks at the effects of both these outcomes on the type of scientific knowledge produced and the uses to which it is applied.

The restructuring of research organisations and funding mechanisms changes the patterns of interaction which lead to the production of scientific knowledge. The new structures reflect the extent to which interaction accords with the norms of techno-economism rather than the norms of science. Similarly criteria for prioritisation, selection and evaluation reflect the relative values which validate scientific competence. These may be generated by the international attentive public, by governments sanctioning the use of public funds, and by market forces which decide the commercial potential of the knowledge produced. The type of knowledge produced will also reflect these values. In the ideal world of the basic scientist, knowledge adds to a body of rigourously-tested ideas which is universally accessible to all scientists. Techno-economism values applied science which can be used to further national economic production. In a privatised, competitive, global economic system knowledge and ideas are commodities to be accumulated and exploited by individual firms and protected from competitors by internationally-recognised rules on intellectual property.

As we saw in chapter 3 which discussed the orientation of science policy, policy based on techno-economistic objectives requires different ways of organising the production of scientific knowledge from one based on nationalistic and cultural objectives. Governments need scientists to re-orient their production away from scientific values and towards techno-economistic values. This can be achieved either through the imposition of government control over research activities, or through influencing the scientific community to accept the new objectives in return for some measure of retained autonomy in the organisation of research. The following section examines how restructuring has been achieved in the four subsectors of the science system under examination.

1. HIGHER EDUCATION

The organisation of the production of scientific knowledge in the higher education sector has changed in several ways. Firstly, the focus of the production of scientific knowledge has changed from individual researchers in individual universities pursuing projects of international competence and excellence to one in which the focus is on teams of workers from the tertiary sector co-operating with researchers from government research agencies and private industry to produce excellent work of relevance to economic production. Secondly, the sector has increased both numerically and functionally to include tertiary education institutions outside the university system.

1.1 Research organisation in 1965: individual excellence

In 1961 the Commonwealth government assumed the major responsibility for funding tertiary research activities. Until 1965 the fifteen existing universities each received an allocation from the Special Research Grant based on 'their comparative general level of postgraduate activity'. Total autonomy was granted by the Australian Universities Commission (AUC) to the universities in deciding upon the internal allocation of these funds. In 1965 the Commonwealth government introduced the ARGS scheme to be used for funding university research on a competitive basis between individual researchers or projects irrespective of the research record of the university in which the researcher worked.[1]

In response the AUC reminded university research committees and individual researchers of the need to use these new funds with caution:

> The Commission believes that university science departments also have a national responsibility to develop researches in areas of applied science *provided they represent the proper intellectual challenge.* The alert intelligence of a good research man is likely to uncover in an applied research project many problems which have all the qualities of basic research. [emphasis added].[2]

In addition the Commision counselled universities to adopt a conservative approach to the areas of research they funded:

> Universities cannot all aspire to be in the forefront of research activities in every discipline. Australia has neither the men nor the money to achieve this, and to attempt to do so can lead only to mediocrity. The time would seem to have arrived when universities in Australia should give thought to co-operative arrangements.

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1 Australian Universities Commission, *Third Report*, pp. 591-815.
2 Ibid., p. 669.

> ...The Commission does not suggest that this co-operation should take the form of specialist institutes off the campus as this would inevitably lead to a weakening of the link between the two prime responsibilities of universities - teaching and research.[3]

Throughout the 1970s the majority of research in Australian universities continued to be conducted on the basis of individual excellence linked to the training of new scientists. As noted in the previous chapter, there was a minor degree of prioritisation in the earmarking of some research funds for marine and upper atmosphere research.

1.2 Research organisation in 1990: concentration, co-operation and selectivity

By the late 1970s the number of researchers claiming excellence had outstripped the funds available in the ARGC scheme. Scientists began to lobby the Fraser government for a different type of research organisation in higher education. The first ASTEC Report in 1978 endorsed the University Commission's call for another level of grants which would sustain 'Centres of Concentration' by the employment of an 'appropriate' mix of trained, rather than training, researchers.[4]

The government responded by establishing, in 1981, a Commonwealth Research Centres of Excellence Committee. The terms of reference of the Committee outlined the characteristics of the centres:

- they should be organised as a concentration of researchers and resources:
- they should undertake research likely to lead to a 'significant and major' development of knowledge;
- they should be led by a researcher with international recognition in the area of research;
- they could be established off campus in co-operation with research organisations from other sectors but the funds would be allocated through the university system;
- the Committee was to consult ASTEC, the ARGC, the NH&MRC and the University Council of CTEC: '...as it considers appropriate'.[5]

By making consultation optional these terms of reference virtually gave the Committee *carte blanche* in deciding how the funds should be allocated. In 1982 ten research centres were established in the following areas of research:

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3 Ibid., p. 670.

4 ASTEC, *Science and Technology in Australia, 1977-78,* vol. 1A, pp. 88-89.
The suggestion that universities should concentrate their research efforts was first published by the Universities Commission in its Fifth Report in 1975 and endorsed by the first OECD Report on science and technology in Australia.
OECD, *Examiner's Report on Science and Technology in Australia,* 1974, pp. 30-31.

5 Commonwealth Tertiary Education Commission, *Review of Commonwealth Special Research Centres,* Parl. Paper 103 , Canberra, 1987, Attachment A.

- clinical immunology;
- cancer and transplantation;
- gene technology;
- nerve muscle research;
- neurobiology;
- environmental fluid dynamics;
- mathematical analysis;
- plant cell biology;
- microelectronics;
- policy studies.

The Commonwealth Research Centres of Excellence Committee noted in its report that twice the number of centres could have been funded, without compromising the required standards of excellence, if sufficient funds had been available. This observation led the University Council of CTEC to recommend the establishment of Key Centres of Teaching and Research which would foster excellence across a wider range of disciplines and including researchers working in advanced education insitutions other than universities. In the Council's opinion such centres would:

> ... lead to a valuable concentration of effort and could be an important means by which higher education responds to emerging national needs to develop expertise in particular fields, especially in the natural and social sciences, technology and other areas important to the process of national development.[6]

The rationale for Key Centres was to broaden the focus of the concentration of research resources to include objectives of social relevance in addition to academic notions of excellence. This required the exercise of selection of areas of research considered to be relevant to 'emerging national needs'. The government responded quickly to the proposal and in 1985 seven such centres were established, followed by fifteen in 1988 and another ten in 1989. By 1990 there were therefore 32 Key Centres of Teaching and Research of which 19 were concerned with the natural sciences and computing in the following areas:

advanced computing science;
knowledge-based systems;
software technology;
statistical science;
land information studies;
aquaculture;
food industry development;
dryland agriculture and land use systems;
Antarctic and Southern Ocean studies;
advanced manufacturing and industrial automation.[7]
resource exploration;
school of mines;
economic geology;
petroleum geology and geophysics;
strategic mineral deposits;
ore deposit & exploration studies;
toxicology;
advanced materials technology;

6 Commonwealth Tertiary Education Commission, *Report for the 1985-87 Triennium,* vol. 1, Part 3, pp. 100-101.

7 Two centres, those of statistical studies and petroleum geology, were terminated in 1991; and three others, aquaculture, ore deposit and Antactic Studies, became Co-operative Research Centres in 1991-92.
Scitech Technology Directory 1992 Edition, p. 54.

A comparison with the fields of research of the Special Research Centres set out above shows a marked shift from predominantly medical research to research into resource industries, and the information technology studies which underly high technology industries.

The location of the centres has also changed: 25 per cent of the 30 centres are situated in existing or former Institutes of Technology or Colleges of Advanced Education.[8] When the Key Centres were first established in 1985 higher education institutions in Australia were in a binary system of universities and other institutions. It was unusual for non-university institutions to be awarded research grants. After the introduction of the Unified National System (UNS) in 1987-88, researchers in non-university higher education institutions could compete for research resources.

The second major change in the organisation of research in higher education has been the introduction, in 1990, of the Co-operative Research Centres (CRCs) designed to encourage collaboration between higher education, public sector and private sector research agencies. The Centres are the initiative of the first Chief Scientist, Ralph Slatyer, though the idea was mooted as long ago as 1965 in the Vernon Report.[9] The Co-operative Research Centres Program, even though it is an initiative linked most closely with the higher education system (the participation of at least one higher education research institute for each centre is mandatory), was introduced, and continues to be administered by the Department of the Prime Minister and Cabinet.[10]

The basic concept of the CRCs is that there should be a three-way interaction between the users of research in economic production and public service, and the producers of research in all types of research organisation. Each centre is intended to foster the involvement of researchers in the higher education sector, in public sector research organisations, and producers in both the private and public sectors, at an early stage in the development of research programs. Researchers being trained in all sectors will learn how to design their programs to accommodate the needs of end-users of their results. A key requirement of participation in the program is a detailed strategy for the application of research results and a commitment by all participants to

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8 Ibid..

9 The Committee concluded that:

> Research and development in industry can be advanced in a number of ways: by closer contacts between industry and university research, including the financing by industry of work in particular fields; *by the development of co-operative research institutions*; and through collaboration with CSIRO [emphasis added].

Australia, Committee of Economic Enquiry, *Report 1965,* p. 424.

10 A note in Budget Paper no., 1990-91 said:

> Initial administration of the scheme will be undertaken by a management committee appointed by the Prime Minister with administrative support located within the Deaprtment of Prime Minister and Cabinet. When the scheme is fully developed administration will be appsed to the appropriate operating area of Government.

Australia, *Budget Paper no. 1: Budget Statements 1990-91,* 3.322.

fund at least fifty per cent of the cost of the Centres. An individual Centre may consist of several geographically-dispersed units linked by a common, specially-appointed management.[11]

The importance of the concept in achieving science policy objectives is underlined by the level of public funds allocated to the centres. Eventually there will be 65 CRCs for which annual government funding will reach $165 million (in 1990 dollars) by 1995. This will almost double the $176m spent on higher education research in 1990.[12]

By 1992 there were 91 specialised research centres funded through the Department of Education, Employment and Training. These consisted of 26 Special Research Centres, 31 Key Centres of Teaching and Research and 34 Co-operative Research Centres (increasing to 50 in late 1992). In addition to these centres funded through DEET there was an enormous increase in the 1980s of higher education research centres funded outside the Key/ Special/ Co-operative Research Centre system. In 1992 the Centre for Research Policy at Wollongong University undertook a survey of institutions within the 34 universities of the UNS and found that there were 888 such centres already established and another 200 in the process of formation.[13] Figure 6.1 shows the rate at which research centres in the natural sciences grew between 1980 and 1992.
The data show that the number of centres increased slowly until 1984 and tripled after the introduction of the UNS, and the restructuring of university research funding, in 1988.[14] In 1980 there were approximately 33 research centres in the natural sciences some of which were established in that year, others were of longer-standing. Almost half the centres in 1980 were in the field of medicine and health. Between 1981 and 1984 few centres were established in any discipline. The greatest increase for all disciplines came between 1988 and 1991. Research in the traditional physical sciences have been the slowest to adopt the research centre mode of organisation. The rate of growth decreased after 1991 for all disciplines except information technology, and applied technology and engineering which started from a very low base. In 1980 there was no selectivity in the way in which research centres were funded therefore it can be assumed that the centres in existence then were the product of factors internal to

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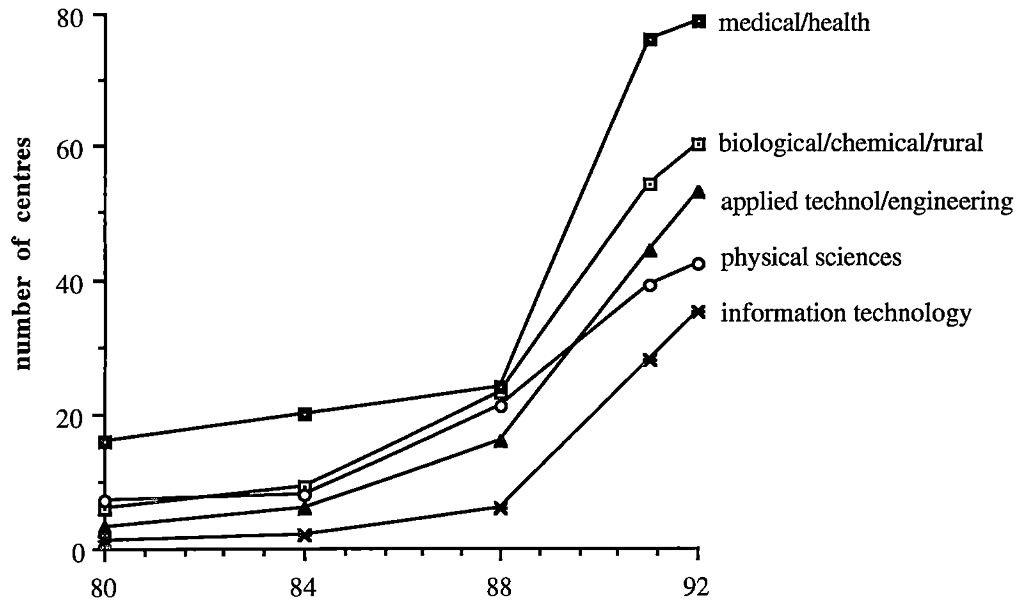
11 Department of the Prime Minister & Cabinet, *Co-operative Research Centres Program: Round Three Applications Guide,* pp. 4-10.

12 Department of the Prime Minister & Cabinet, *Annual Report 1990-91,* AGPS, 1191, pp. 86-87.

13 The Centre for Research Policy, *Concentration and Collaboration: Research Centres in the the Australian National University System,* p. 20.

14 The Centre for Research Policy received 610 replies to the survey but not all institutions completed all the survey questions. The data base for figure 6.1 includes 476 research centres of which 269 (57%) were in the natural and applied sciences.
Ibid., pp. 3-4.

Figure 6.1: The rate of establishment of higher education research centres in the natural sciences, 1980-92



Data source: The Centre for Research Policy, *Concentration and Collaboration,* 1992, Table 9, p. 20.

the higher education research system. Since the election of the first Hawke government the emphasis has increasingly been on selectivity and concentration of research resources and this has been reflected in the pattern of establishment of research centres.

1.3 From informal groups to organised teams

The majority of government-funded centres are required to collaborate with research agencies and the producers of goods and services in the public and private sectors. This indicates that teamwork and collaboration have taken over from individual effort as the preferred mode of research organisation. The shift has been more marked in the universities formed after the establishment of the UNS, and in other institutions of higher education. The Wollongong study examined the question of whether funding for research centres was focussed on teams or on individual researchers, and whether this varied according to the age of the university. It found that funding for the majority of centres is directed to teams rather than individuals but that this was more marked in the universities created since 1987. In the 'old', pre-Second World War universities the distribution was 56 per cent group funding to 46 per cent individual funding, but in the 'new' post-1987 universities the distribution is 63 per cent group to 37 per cent individual funding. This may indicate a reluctance among researchers in the traditional mode of research organisation to accept the new structures, or that researchers in the old universities can still attract research funding on an individual basis.

To overcome this reluctance the Hawke government has also used the grants system to restructure the organisation of research in universities. In 1984 the ARGC announced a four-part categorisation of grants designed to encourage the development of teams of research excellence and to give young researchers a career structure independent of individual projects. The Committee also flagged the need for the Scheme to provide teaching release to give researchers time to write up their project results. These initiatives on the part of the Committee were expanding its role into the organisation of research effort in universities.[15]

Summary: higher education

The patterns of research organisation since 1965 show that change will only occur in the higher education system when governments tie funding to preferred modes of organisation. Outcomes are not changed if decision-makers in the subgovernment expect scientists automatically to change their objectives in line with government expectations. The myth of the god-professor persisted as long as the funding system was centred around the premise of 'the one good man'. Governments seeking change had to tailor funding to specific forms of interaction. By changing the bases of resource allocation, the criteria by which such funds were awarded; the composition of the funding bodies; and by suggesting new forms of interaction between individual and organisational actors in the science system, governments can realign the objectives of higher education researchers towards more economically and socially relevant ends.

2. CSIRO: 'FIEFDOMS' TO CORPORATIONS

Chapter five showed how, by 1990, CSIRO had become the largest research organisation in Australia in terms of financial resources with 24 per cent of all direct appropriations to research being allocated to the organisation, and how the Hawke government imposed new external funding requirements on the Organisation as a means of making CSIRO researchers more accountable for the public resources they consume in the production of scientific knowledge. The government has also restructured the Organisation to complement and strengthen these financial incentives towards achieving techno-economistic objectives as well as scientific objectives. This required changing the organisational culture of CSIRO to reflect changing policy objectives. The organisational objectives of CSIRO, as stated in the enabling Act, had remained virtually unchanged since 1920[16] Administration of the Organisation has

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15 AARGC, *Report on Grants Approved for 1984*, pp. 6-7.

16 In fact the words detailing the functions of the Organisation are alomost identical to those used for the original Institute of Science and Industry Act (no. 22 of 1920), through the Science and

changed from one based on the autonomy of researchers to a corporate-based internal and external interdependence. The principle shift in the organisation of CSIRO between 1965 and 1990 has been from one of isolated divisions aligned with scientific disciplines to one in which research is performed in institutes aligned with sectors of industrial production. Table 6.1. illustrates the changes.

In 1965 the production of scientific knowledge in CSIRO was organised in, at best, loosely-coupled divisions based either on scientific subjects or disciplines (eg. Chemical Physics), or on projects or industries (e.g. Forest Products).[17] The divisions were autonomous in the direction of their research with individual scientists deciding priorities within the broad parameters of a division's responsibilities. There existed what Dr John Stocker calls 'a fiefdom mentality'.[18] Divisional Chiefs provided 'inspiration' to the scientists and secured the necessary allocation of resources to fund their research.[19] White describes this management ethos:

> David Rivett taught us how to manage a research team which, through notable scientific achievement, could contribute to the practical interests of Australia....Once convinced of the validity of their findings he would back them publicly against the views of conservative practical opinion.[20]

Industry Research Acts (no. 20 of 1926 and no. 13 of 1949) until alteration in the Science and Industry Research Legislation Amendment Act in 1986 (no. 121 of 1986).

17 Table 1 is constructed to reflect the way in which divisions/institutes were discussed in contemporary CSIRO publications. The slightly chaotic grouping of 1965 follows a vaguely chronological and geographical schema of dispersed research units. The 1965 Annual Report gave no organisational chart and no description of the way in which the separate parts of the Organisation were connected. In contrast the 1990 publications are redolent of the era of coporatism in government organisations with mission statements, operational plans and budgets for each Institute and Division, photograhs of the Board and an inspirational message from the then Chairperson, Neville Wran.

18 John Stocker, 'CSIRO's knight lowers the drawbridge to research', *Australian,* November 6 1990, pp. 40-42.

19 Gillespie, 'Research Management in the Commonwealth Scientific and Industrial Research Organization, Australia', p. 19.

20 White, 'CSIR to CSIRO', pp. 292-293.
The tradition was written into the 1949 Act in the form of Section 8 (2) which states: 'The Organization shall consist of the members of the Executive, and of the Officers, of the Organization...'. This survived into the 1986 Act but was not part of the Acts of 1920 or 1926.
Sir David Rivett himself summarised these ideas in 1951 at an Australian National University Seminar held in Canberra to celebrate the Jubilee of the Commonwealth of Australia. He expressed mistrust of comprehensive research programs on the grounds of the serendipitous nature of scientific research and was thankful that no-one in power in Australia appeared to want to direct science that way. Scientists needed autonomy, not only in the conduct of scientific research, but in controlling their conditions of work, status and pay. Scientific organisations should not be allowed to grow beyond a certain size because of the dangers of developing bureaucratic hierarchies which would stifle autonomy. Too much emphasis on teamwork would hold back those who, by natural talents, could lead the rest in discoveries.
Sir David Rivett, Reported in *Science in Australia,* Proceeds of a Seminar organised by the Australian National University on the Occasion of the Jubilee of the Commonwealth of Australia, Canberra, July 24-27, 1951, F.W. Cheshire, Melbourne, 1951, pp. 161-163.

Table 6.1 Changes in CSIRO structure, 1965 to 1990

1965	1990
Animal Research Laboratories	**Information Science & Engineering**
Animal Genetics	Information Technology
Animal Health	Mathematics and Statistics
Animal Physiology	Radiophysics
Nutritional Biochemistry	Australia Telescope
Plant Industry	Office of Space Science & Applications
Entomology & Wildlife	**Industrial Technologies**
Entomology	Applied Physics
Wildlife Research	Biomolecular Engineering
Soils	Chemicals and Polymers
Tropical Pastures	Manufacturing Technology
Land Research	Materials Science &Technology
Horticulture And Irrigation	**Minerals, Energy & Construction**
Horticultural Research	Building, Construction & Engineering
Irrigation Research	Exploration Geoscience
Processing Agricultural Products	Geomechanics
Food Preservation	Mineral and Process Engineering
Dairy Research	Mineral Products
Wheat Research	Coal and Energy Technology
Wool Research	**Animal Production & Processing**
Chemical Research Of Industrial Interest	Animal Health
Chemical Research Laboratories	Animal Production
Protein Chemistry	Tropical Animal Production
Fisheries And Oceanography	Food Processing
Physical Research Of Industrial Interest	Human Nutrition
National Standards Laboratory	Wool Technology
Processing Mineral Products	**Plant Production And Processing**
Coal Research	Entomology
Chemical Research Laboratories	Forest Products
Mining and Metallurgy	Forestry
Processing Of Forest Products	Horticulture
Forest Products	Plant Industry
General Physical Research	Tropical Crops and Pastures
Radiophysics	Soils
Meteorological Physics	**Natural Resources & Environment**
Upper Atmosphere	Atmospheric Research
Radio Research Board	Fisheries
	Oceanography
General Industrial Research	Water Resources
Building Research	Wildlife and Ecology
Tribophysics	Centre for Environmental Mechanics
Soil Mechanics	
Mechanical Engineering	
Research Services	**Corporate Services**
Other Services	**Sirotech**
Executive	**Board**
Chairman	Chairman
8 others	Chief Executive
Advisory Council	8 others
Chairman	**Csiro Executive Committee**
8 Executive members	Chief Executive
18 co-opted members	6 Institute Directors
6 State Committee Chairmen	Chief Executive Sirotech
State Committees	Director Corporate Services
Chairman	**Advisory Committees**
15-35 members	at Institute and Divisional levels

Source: Australia, Commonwealth Scientific and Industrial Research Organisation, *Eighteenth Annual Report,* Parliamentary Papers, Commonwealth government Printer, Canberra, 1964-65-66, p. 8. CSIRO, CSIRO Research 1990-91: Directory of CSIRO Research Programs, CSIRO, Canberra, 1991, pp. x-xii.

The problem for government is that scientific validity or excellence does not always ensure achievement of CSIRO's statutory obligations of application to industrial needs, as the Science Task Force pointed out in 1975.[21]

The Task Force agreed with the OECD that under such arrangements there exists a continuing tendency for the objectives of the Organisation to become isolated from the needs of the users of research in industry. The solution is to develop executive mechanisms which facilitate intra- and inter-organisational linkages particularly between scientists and users of research.[22] The Birch Committee on CSIRO suggested that the solution would be: to regroup Divisions into Institutes based on 'national development sectors' rather than natural resources or scientific disciplines; to make Institute Directors members of the Executive of the Organisation and responsible for maintaining industry linkages; and to give the Executive greater planning and evaluatory capacity through the provision of economic and industrial expertise in the form of a Planning and Evaluation Advisory Unit.[23]

By 1986 the OECD Examiners found that CSIRO was making 'some efforts to bridge the gap between its laboratory needs and the needs of manufacturing'. The tension between maintaining cohesion in a large multi-disciplinary research organisation and developing closer ties with industry was proving difficult to achieve. The Examiners concluded that the temptation was to set strategic goals which fitted organisational interests rather than industry needs. They recommended the introduction of a corporate planning model rather than further restructuring.[24] Without considerable political commitment the norms of science were still proving resilient to techno-economism.

In 1985 ASTEC too had recommended that research be even more tightly oriented to external needs by introducing a partial user-pays arrangement for CSIRO services to industry, by allowing the movement of scientists in and out of the Organisation without loss of superannuation privileges, and by re-organising the existing executive machinery from one based on part-time advisory members to a fully corporate Board with the capacity to dismiss the Chief Executive.[25] In 1986 the final steps towards partial corporatisation of CSIRO began with the amendment of the Science and Industry Act.[26] Subsequent events have added to the broad objective that

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21 RCAGA, Science Task Force, *Towards Diversity and Adaptability,* p. 57.

22 OECD, *Examiner's Report on Science and Technology in Australia,* 1974, p. 17.

23 Australia, *Independent Inquiry into CSIRO*, pp. 47, 80 & 83.

24 The Examiners cited the case of research into the development of a high speed passenger train which had no support from Australian Railways or transport manufacturers. The train was a particular interest of J.P. Wild who was Chairman of CSIRO from 1977 to 1985. OECD, *Reviews of National Science and Technology Policy: Australia 1985,*1986, pp. 34-35.

25 ASTEC, *Future Directions for CSIRO,* Parl. Paper no. 470 of 1985, pp. 7-9.

26 It is difficult to ascertain the exact sequence of advice to Government at this time. Although the OECD Report was not published until 1986, the Review Meeting, at which the Examiners explain their findings to invited representatives of Government and interest groups, took place on

CSIRO should be responsible for producing most of the strategic research in Australia while at the same time increasing the amount of tactical research undertaken for, and directly paid for by industry.[27]

The most significant changes have been:

- strengthening the role of the Minister responsible for CSIRO by inserting in the Science and Industry Act a clause (Section 13 (1)) which allows the Minister to issue to the Board a set of guidelines with which the Board must ensure compliance;

- enhancing the power of the Chief Executive to be responsible for the affairs of the Organisation at the same time as making that position accountable to a part-time Board appointed by the Governor-General and led by a part-time Chairperson also appointed by the Governor-General (Section 14);

- writing into the Act the requirement for Annual and Strategic Plans to be submitted by the Board to the Minister with the requirement that only research approved under the plan can be undertaken by the Organisation (Part VII 36 (1));

- commissioning management consultants McKinsey and Co. to design management structures for each Institute which would both serve existing businesses and research users, and allow for the development of new industries;

- introducing the requirement that up to 30 per cent of the income of each Division should be derived from external sources;

- allowing individual scientists to benefit financially from developments of their research, and introducing a system of discretionary fiancial rewards by the Chief Executive for excellent research which cannot be commercialised;[28]

- ensuring a process of prioritisation and evaluation which allows input from all levels of the Organisation;

- appointing for the first time in CSIRO's history a Chief Executive from outside the Organisation.

The result has been to make CSIRO both more outward-looking, in terms of two-way interaction with the community, and more aware of the need to co-ordinate research within the Organisation.[29]

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7 April 1985. On 7 May 1985 the Prime Minister announced that ASTEC would be conducting a review of CSIRO. In the June issue of *Search* the then CSIRO Chairman, J.P. Wild, wrote an article suggesting that CSIRO should not be singled out as a scapegoat for the research deficiencies of the private sector. ASTEC presented its Report in November 1985.

27 The Hon. Barry O. Jones, 'The Role of Government Research Organisations and Tertiary Institutions in Basic, Applied Research and Experimental Development', *Annual General Meeting Symposium,* Australian Academy of Science, Canberra, 1986, pp. 12-23, p. 16.

28 Dr Oliver Mayo, Chief, Division of Animal Production, CSIRO, Interview, 4.11.89.

29 Dr John Stocker, CSIRO Chief Executive since 1990, tells of how he had to change the attitude of CSIRO scientists that consulting users and other disciplines would not harm the scientific rigour of their research. He gives the example of an historic meeting of CSIRO scientists from

SUMMARY CSIRO

The government's policy objective has been to change the perspective of both CSIRO scientists and the industrial producers they serve. The interaction is two-way with individual scientists in field and laboratory being given the opportunity to persuade management and users that investment in a particular area will be of value to the industry. Advisory Councils exist at the level of Divisions to keep the scientists aware of industry needs and for scientists to persuade industrial managers of the commercial viabiliy of new research. At the same time the operational plan imposes a financial discipline which keeps scientists aware of the need to contain their creativity within the bounds of national priorities.[30] The organisational framework within which research action takes place in CSIRO has been re-structured so that it fits the objectives of techno-economism rather than the autonomic prescriptions of scientific ideology. Eventually this should change the way in which scientists perceive their work, especially if the higher education system trains young scientists to organise their creativity in line with industry's needs.

3. MANUFACTURING INDUSTRY

The relationship between manufacturing industry and the Commonwealth government has been the most problematic of all the science policy sectors because of the often contentious issue of government intervention in the market. By contrast with the rural sector of production, Australian governments have traditionally shown a reluctance to intervene in the management of private sector manufacturing research and development. On their part, as noted in chapter five, manufacturers in Australia have demonstrated a marked reluctance to consider research and development as part of normal production activity. Whereas by 1965 research and development was an intergral part of rural production, in non-rural production the interaction between the science system and industry which had been developed in the second world war had not become institutionalised. Since 1965 there has been a change in the mechanisms of interaction and in the policy outcome in the form of the amount of research and development undertaken by private manufacturing industry and its commercialisation. The change was incremental until 1986 at which point the incentives offered by the government were restructured: their size, the type of activity which was deemed to be

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different divisions who met in 1990 to discuss their mutual work on land and soil care and to formulate ways in which the findings could be communicated to the public. Incredibly, a formal event of this kind had never happened before. The scientists, who had been initially sceptical about the process, later agreed that their scientific creativity had been enhanced by the understanding that their work was valued in the community.
Stocker, 'CSIRO's knight lowers the drawbridge to research', pp. 40-42.

30 Ibid..

eligible for subsidy, and the direction in which the results of the incentives were to be applied were all transformed.

3.1 The incentives schemes

Chapter five indicated that, in the science policy community of secondary industry, the most significant form of interaction between Commonwealth governments and private firms has been the system of grants and subsidies for research and development. The industrial research and development grants scheme introduced in 1967 remained largely unchanged until 1986 when the system changed from being grant-based to being tax-based. The changes have substantially altered the amount of research conducted in the sector of manufacturing industry. The changes began in the late 1970s under the Fraser government but were not effective until the election of the Hawke government with its policy of radical techno-economism objectives for re-structuring manufacturing industry in Australia to be science-based.

3.1.a AIRDGS:1967-1976

The Australian Industrial Research and Development Grants Scheme (AIRDGS), stated that:

> ..."industrial research and development", means systematic experimentation or analysis in a field of science or technology carried out by the company concerned, or procured by it to be carried out, in Australia with the object of -
> (a) acquiring knowledge which may be of use for the purpose of devising or developing new or improved material products or new or improved processes for or in connexion with the production or use of material products; or
> (b) applying knowledge for the purpose referred to in the last preceding paragraph; ...[31]

Although this definition seems fairly broad, certain activities were excluded from the Scheme. These non-eligible activities, at the time considered by Whitlam to be essential to the commercialisation of research, included:

methods engineering	operational research
routine property control	routine materials testing
market research	sales promotion
feasibility studies	management studies
labour efficiency surveys	technical services to customers
exploration & prospecting design work.[32]	

Their exclusion indicates the lack of understanding of commercial processes by the decision-makers who designed the scheme. The Scheme was administered by a Board

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[31] Lamberton, *Science, Technology and the Australian Economy,* Tudor Press, Sydney, 1970, Section 5 of the Industrial Research and Development Grants Act 1967, given in Appendix G, pp. 248-265.

[32] Australia, House of Representatives 1967, *Debates,* vol. HR55, p. 2341.

of three members assisted by an Advisory Committee of eight, four of whom were public sector research agency managers and four of whom were managers or directors of private manufacturing firms.[33]

In 1974 the OECD Science and Technology Examining Panel reported four main criticisms of the scheme. Firstly, the scheme only funded research which was additional to a base year of activity and therefore not pre-selected for maximum commercial potential. Secondly, because the scheme worked by refunding monies already spent, large companies (often under foreign control) benefited more than small companies who could not make the initial expenditure. Thirdly, the fact that the subsidies were taxable reduced their worth to 25 per cent; and finally, the $200,000 upper limit precluded research and development on large prototype projects. The OECD recommended three basic principles for an industrial research and development aid scheme:

- enterprises should be judged on detailed proposals;
- enterprises should share up to 50 per cent of the costs of research;
- enterprises should refund the research costs of successful projects and government should receive a proportion of royalties.[34]

By 1976 the scheme was in considerable trouble due to the increasing demands of industry at a time when the government had reduced available funds to 1967 levels in real terms.

3.1.b AIRDIS: 1976-86

In 1976 the Australian Research and Development Incentives Scheme was established to:

> ...promote the development and improve the efficiency of Australian industry by encouraging industrial research and development in Australia in matters relating to science and technology.[35]

Despite the OECD criticisms the definition of research and development differed from the 1967 definition only in its inclusion of environmental concerns and a slight relaxation of the stipulation that products and processes should be 'new', to one that they should be 'substantially improved'.

However, the new scheme differed from the old in several ways: in its structure; in the type of grants offered; and in the criteria by which companies were selected for grants. The new structure enhanced the power of the Board and the Minister, and decreased the influence of the Advisory Committee which was reduced to three members who made decisions about the professional status of employees whose

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33 Ibid., pp. 60-61.

34 OECD, *Examiner's Report on Science and Technology in Australia,* 1974, pp. 21-23.

35 *Industrial Research and Development Incentives Act 1976,* (no. 85), (Cwlth) Section 3, pp. 872-903.

activities were to be subsidised. The Board was enlarged to a maximum of four part-time members with a full-time chairman and functioned as a mechanism for legitimising the activities claimed as research and development by applicant firms by declaring certain agencies as approved research organisations. The scheme was placed under the jurisdiction of the Minister for Productivity.

The Board's decisions on the allocations of grants were subject to ministerial guidelines. These ranged from concern with the national economic usefulness of the product to concern about the conduct of the applicant company in relation to the research activity being subsidised. For the first time since 1967 Section 39 of the Act was invoked allowing the Minister to authorise the Board to make arrangements for the carrying out of specific projects of industrial research which the Minister determined to be in the public interest. These grants were designed to encourage co-operation between government and industry on projects which otherwise would not be undertaken because of lack of short-term commercial viability but which were, in the long-term of national interest.[36] The government was beginning to make decisions about the type of industrial research and development which should be undertaken.

In the early 1980s the Board was in an unenviable position. There had been eight reports or enquiries into technology, science and industry which addressed the question of industrial restructuring in Australia.[37] The Auditor-General's Report in particular criticised the scheme for operating without an adequate understanding of the effects of market forces on the use of scientific knowledge in productive enterprises. At the same time the Fraser government did not seem willing to allocate funds either for re-structuring or even for the competent administration of the incentive scheme for industrial research.[38] The policy which emerged in 1980-82 was a redefinition of the existing scheme with new areas of research and grant conditions which widened considerably the Board's field of action. The establishment of a technical committee with the capacity to advise on the potential market viability of new scientific industrial knowledge effectively gave the government the sanction of witholding grants from companies on the grounds of market competence as well as scientific competence.[39]

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[36] AIRDIB, *Annual Report 1985-86,* p.9.

[37] See chapter 4, footnote #101.

[38] The Chairman's letters to the Minister in the AIRDIB Annual Reports for 1979-82 indicate an increasing frustration about the lack of concern by the Government that firms needed funds to be immediately available in order to minimise the development period of new products.
AIRDIB, *Annual Report 1970-80,* p. iii.
AIRDIB, *Annual Report 1980-81,* p. iii.
AIRDIB, *Annual Report 1981-82,* p. iii.

[39] The changes were:
- inclusion of construction R&D;
- inclusion of software R&D;
- increases to commencement grants;

3.1.c The GIRD scheme: 1986-1990

In 1983 the AIRDIS scheme was placed under the auspices of the new Department of Science. The Minister promptly enlarged the Board to include such scientist-entrepreneurs as Dr Alexandra Pucci who had started Australian Monoclonal Development, and Sir Gustav Nossal whose management of the Walter and Eliza Hall had kept that institution at the forefront of world microbiology. Also on the Board was a market specialist, Peter Redlich of Redlich Holdings. The Board were given a staff of 59 in the Industrial Research and Development Branch of the Department of Science, and a new Public Relations Committee to enhance reciprocal understanding of the incentives offered by the government to industry. One such exercise was the canvassing by the Board of the opinions of the scientific community (at meetings held in the six mainland capital cities and through mailed questionaires) about the type of incentive preferred in the industry sector.[40]

The new scheme operates under the Industry Research and Devlopment Act 1986, the objective of which is to 'promote the development, and improve the efficiency and international competitiveness, of Australian industry, by the provision of assistance for research and development activities.'[41] Unlike the changes in 1976 the new Act redefines research and development in such a way as to enlarge the scope of government intervention in manufacturing research:

- restrictions on the payment of commencement grants to exclude companies receiving R&D grants for 5 years; or spending more than $250,000 on R&D in the 8 years prior to application;
- advance payments to be made only where firms provide adequate security for any repayments that may be necessary
- Advisory Committee replaced by a Technical Standing Committee
- enlargement of the Board to comprise a part-time Chairman, an Executive Member and 6-10 other part-time members;
- broadening of powers and functions of Board to include:
  - i) increased communication between the Board & members of IR&D 'constituency' in Australia;
  - ii) the fostering of interdepartmental co-operation in industrial R&D;
  - iii) the provision of Ministerial advice on incentives for industrial R&D.

AIRDIB, *Annual Report 1981-82.*

40 The Board reported that the unanimous view was that both tax and grant incentives were necessary but that the present scheme was unlikely to be able to provide the flexibility and depth of evaluation necessary to be effective under existing administrative constraints, particularly the lack of autonomy in the allocation of administrative resources because of the need to operate through the Department of Industry, Technology and Commerce and the Public Service Board. In 1986 a new incentive scheme was established under legislation designed after consultation with industry, research organisations, professional organisations and universities.
AIRDIB, *Annual Report 1983-84,* p. iii.

41 Industry Research and Development Act no. 89 of 1986, Section 3.

> ..."research and development activities" means systematic investigation or experimentation activities -
> (a) that involve innovation, technology transfer into Australia or technical risk;
> (b) that are carried out in Australia
> (c) the object of which is new knowledge (with or without a specific practical application) or new or improved materials, products, devices, processes or services:...[42]

The new Board has fourteen members, ten of whom are scientists, economists or lawyers in private firms.[43] The Board is advised in its functions by eight Committees:

> Tax Concession Committee;
> Discretionary Grants Committee;
> National Procurement Development Committee;
> Communications Technology Committee;
> Biotechnology Committee;
> Information Technology Committee;
> Manufacturing and Materials Technology Committee;
> Waste and Environmental Management Technology Committee.

In addition to administering the Act, advising the Minister on research and development incentives for industry, monitoring the effectiveness of the programs in the scheme and maintaining State-based field offices, the Board is also currently responsible for fostering relations between Australian and overseas research and development activities. There is also a Research Committee which has an overseeing role in advising the Board on such macro-structural issues as the distribution of industrial research and development and the identification of which factors facilitiate and which factors inhibit commercialisation of industrial research and development.

There are now five main incentives programs for government support of industrial research and development: a 150% Tax Concession, Discretionary Grants, Generic Technology Grants, the National Procurement Development Program, and the National Teaching Company Scheme. Each scheme (described in chapter 5) affects the organisation of research in the private manufacturing sector in different ways.

3.1.c.i The 150 % tax concession

The concession applies to research and development activities which do not attract other government assistance, the results of which will be exploited on normal commercial terms to the benefit of Australia. Its use is restricted to companies incorporated in Australia undertaking research in Australia. The tax concession is open to all companies undertaking activity which fulfills the statutory definition of research and development. There are no priority areas.

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42 Industry Research and Development Act no. 89 of 1986, Section 4.
43 IR&DB, *Annual Report 1990-91,* Appendix 1, p. 107.

3.1.c.ii Discretionary grants

Discretionary grants are for small firms beginning to undertake research and development but which do not have enough taxation liabilities to benefit from the tax concession. The Board may only award discretionary grants when it is satisfied that a company in manufacturing, mining, construction or software is planning to undertake research and development from which normal commercial exploitation for the benefit of the Australian economy will ensue, but which would be unable to undertake the project without government support. The grant is also payable for work done in an outside research organisation undertaking work on behalf of two or more companies that fulfil these criteria. In 1991 the scheme was enlarged to include service industries and market research. Funds in the discretionary grants scheme are awarded competitively to areas of government preference or other areas which can prove commercial viability or national economic significance for the products or processes which are developed.

3.1.c.iii Generic Technology Grants

Generic Technology Grants are designed to support pre-competitive strategic research and development in particular new or emerging technologies which are designated by the Minister as being of fundamental significance for industry competitiveness in the 1990s but which are unlikely to develop if left to market forces alone. By 1990 five such technologies had been declared. They are:

Biotechnology;
New Materials Technology;
Information Technology;
Communications Technology;
Waste and Environmental Management Technology.[44]

Generic grants encourage interfirm collaboration in particular areas of production and between these firms and all areas of the science system. They are the closest approximation yet in the relationship between manufacturing industry and government to the collective interaction of the rural research funds and corporations.

3.1.c.iv National Procurement Development Program

The NPDP was established in 1988 to fund projects which encourage government departments and agencies to seek Australian solutions for their forward procurement needs. The program brings together government purchasers and innovative Australian businesses. It is directed at the development, trialling and demonstration end of the research and development process. To qualify projects must demonstrate a sustainable

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44 IR&DB, *Annual Report 1990-91*, p. 240.

competitive advantage in international markets. The NPDP Committee includes representatives from industry and the trade unions.[45]

3.1.c.v National Teaching Company Scheme

In 1984 the government introduced the National Teaching Company Scheme to encourage collaboration between the higher education and industrial sectors through the use of personnel. The government funds research projects in which graduates work in private firms supervised jointly by academics and company personnel to develop new products or processes. The projects may be in a wide spectrum of activities including the areas of manufacturing methodology, marketing, management accounting, design or strategic planning.[46]

Summary: manufacturing industry

ALP governments since 1983 have pursued a policy of restructuring the allocatory system for the public funding of manufacturing research and development in order to address perceived economic needs of decreasing the technological balance of payments by increasing the technological component of exports. Table 6.2 summarises the changing patterns of interaction in the organisation of public resources for manufacturing research.

Table 6.2: Industrial R&D incentives schemes 1967-90

	1967	*1976*	*1981*	*1990*
Board	Chairman (private sector) 2 part-time members	Chairman (private sector) 2-4 part-time members	Chairman (private sector) 6-10 part-time department officer	Chairman (private sector) 12 part-time 2 departmental
Advisory Committee	Chairman 4 public sector research managers 4 private sector managers or directors	Chairman 2 members	Chairman 4 members	Tax Concession; Discretionary Grants; National Procurement Dev.; Biotechnology; Communications; Environmental; Information; Materials & manufacturing;
Other Committees	none	Technical Director 2 scientific or technical staff	Technical Standing Committee Public Relations Committee	Research Committee

45 IIR&DB, *Annual Report 1988-89,* Parl. Paper 23, Canberra, 1990, p. 57.

46 Bureau of Industry Economics, *The National Teaching Company Scheme,* AGPS, Canberra, 1991, p. VII.

The changes simultaneously allow producers greater autonomy in the selection of research to be subsidised and allow governments to direct other funds to selected areas of research. The proliferation of subgovernmental agencies, the enlargement of activities designated as research and development, and the widening of interests represented on the Board, reflect the complexity of the selection processes and the willingness of the government to enlarge the scope of its intervention. However, at the same time, the introduction of the tax concession has both encouraged manufacturing industry to invest in research and development and allowed a wide measure of market demand into the public subsidisation of research.

4. Rural Industry

Rural research has traditionally been undertaken by a wide range of research agencies in Australia: by CSIRO, university researchers, researchers in State higher education institutions and departments of agriculture; and by specialised research institutes. Since 1965 the most significant change in the way research is organised in the rural sector has been the shift in the focus of decision-making in the rural science policy community about which research should be undertaken. In 1965 this was primarily the responsibility of rural producers and scientists. The restructuring of the Rural Research Trust Funds has altered control of the process of prioritisation so that decisions are now taken on the basis of sophisticated economic modelling of potential markets by bureaucrats as much as on the basis of scientists solving existing problems of rural production. The seeds of change were sown in the late 1970s when the Fraser government undertook an enquiry into rural research funding. However, significant change occurred only when the Hawke government restructured the mechanisms of decision-making in the rural research system to reflect government techno-economistic objectives.

4.1 Rural research organisation in 1965

Earlier chapters have shown that the principle of public support for rural research has been a long-term policy of Australian governments, and that the principles were concretised in research structures and funding. By 1965 two main mechanisms had been developed - research associations and research trust funds. *Research associations* are voluntary industry groups partly funded by the Commonwealth government through CSIRO. They employ their own scientists in autonomous institutions.[47,48] *Research trust funds* were established to aid research in particular industries and usually contracted research projects in public or private organisations.

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47 Science and Industry Research Act, no. 13 of 1949, Section 9 (1) (d).

48 In 1965 these were the Wine Research Institute; the Sugar Research Institute; the Bread Research Institute; the Coal Research Institute; and the Australian Leather Research Institute. CSIRO, *Eighteenth Annual Report 1965-66,* p. 218.

It is this form of organisation of research which most closely reflects government objectives for publicy funded research, and which has undergone major restructuring under the ALP governments of the 1980s.

4.2 Changes in rural research funding agencies

In the 1970s both the Whitlam and Fraser governments examined the system of rural research funding in Australia. In 1974 the Whitlam government commissioned a Green Paper on Rural Policy in Australia which was published in 1974. This Report examined the funding of rural research and found that the burden of levies fell unequally throughout the rural community with some industries paying no levies at all. Other criticisms of the system were:

- there was a bias towards producing research of interest to large producers;
- the system produced too much basic scientific knowlege with no specific application in the industry;
- the narrow sectoral base of the trust funds limits the inter-disciplinary nature of the scientific activity. This type of work often generates the most innovative research findings;
- there was not enough research into less established crops with the result that the industry was too narrowly focused in the face of market changes;
- there was not enough emphasis on marketing research.[49]

The Report concluded that rural research should continue to be funded partly by government but that current institutional arrangements mitigated against efficient use of resources. An overall advisory body was needed to ensure that the scientific knowledge produced covered all aspects of rural production, and that the research commissioned by the rural producers should be carried out in as wide a range of institutions as possible in order to stimulate inter-disciplinary innovation and collaboration.[50]

Similar conclusions were reached in the Industries Assistance Commission's (IAC) 1976 report on rural research funding. The IAC supported the principle of government support for rural research and development and concluded that, on the whole, the system of funding provided more benefits than costs to the Australian public. The IAC offered a blueprint for a new system of funding which would maintain the close industry/research community relationship but at the same time reduce the uncertainties of output-based income for the funds and the broader system inefficiencies of lack of research co-ordination. The most significant of the Commission's recommendations for rural research were:

- the establishment of an Agricultural Research Council to advise the Standing Committee on Agriculture on research issues;

49 Australia, *The Principles of Rural Policy in Australia,* paragraphs 5.125-5.190.
50 Ibid., paragraphs 5.245-5.256.

- a new Bureau of Rural Research should manage the trust funds, act as a secretariat for the new Agricultural Research Council, and develop an inventory of research;
- to alleviate the Funds' problems with research costs outstripping income levies should be based on value produced rather than volume produced;
- Rural Research Industry Funds should appoint technical committees to advise on the allocation of research funds.[51]

ASTEC, too, in its first Annual Report, advised Prime Minister Fraser that the proposed Commonwealth Council for Rural Research and Extension (the outcome of the IAC REport) should be given the task of prioritising, co-ordinating and evaluating rural research policy objectives.[52] ASTEC found that rural research in Australia lacked any co-ordination and was in general 'site specific' because there was no overarching, co-ordinating agency at the national level.[53]

The OECD reiterated this theme of the co-ordination of rural research policy in its 1977 Review of Australian science policy. The Organisation approved of the close ties between industry and researcher fostered by the quadripartite (Commonwealth, States, CSIRO, industry funds) system of funding, but recommended the establishment of a central agency to manage the relationship between the rural research system and the global market.[54]

The overall picture is of a research system which was fulfilling its fundamental mission of the short-term needs of its commodity-based clientele but which was not encouraged by its major resource provider, viz. the Commonwealth government, to develop a wider role in articulating the interaction between users of knowledge, producers of knowledge and the wider socio-economic environment.

4.3 The corporatisation of the Trust Funds

1980 heralded a decade of change which began slowly but accelerated from 1983 as the Hawke government began to implement the changes advocated by the various reports of the late 1970s. The issue of the co-ordination and centralisation of advice on rural research was embedded in an ideological debate about States' Rights. The direction of research funded by the Trust Funds was strongly influenced by State-based advisory committees and the scientists who benefited from their funds; and the Fraser government was reluctant to upset the power of the Agricultural Council and the Standing Committee on Agriculture even though the two bodies had traditionally not exerted their statutory rights in that direction.[55]

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51 Industries Assistance Commission, *Financing Rural Research*, pp. 7-9.
52 ASTEC, *Science and Technology in Australia 1977-78*, vol. 1B, p. 25.
53 Ibid., vol. 2, p. 117.
54 OECD, *Review of National Science Policy: Australia 1985*, p. 159
55 Keith O. Campbell, *Australian Agriculture: Reconciling Change and Tradition*, Longman Cheshire, Melbourne, 1980, p. 150.

By 1980 some changes had been made in the direction indicated by the reports. A Commonwealth Council for Rural Research and Extension had been established to advise the Minister on rural research and to evaluate the needs of the funding system; and the Department of Primary Industry was finally required to table an Annual Report documenting the financial activities of the Rural Industry Research Trust Funds for which the Minister had statutory responsibility.[56]

The Hawke government was elected on a platform which contained a science and technology policy with no reference to rural research or the funding thereof.[57] The Minister for Science and Technology considered that such funding should not be cut but that more efficent use should be made of allocations to rural research by the reorganisation of priorities within the system.[58] The government began by establishing a Bureau of Rural Research and continued with a gradual proces of the corporatisation of the Rural Industry Research Trust Funds.

The role of the Bureau is to provide scientific and technical advice on sustainable rural economic activity. However, when it began working in the mid 1980s the Bureau discovered that very little was actually known about where, how and why over five hundred million dollars is spent on rural research in Australia each year. The staff therefore developed a directory of rural research which identifies 73 separate organisations doing rural research in Australia under the definition of the Rural Industries Research Act 1985.[59] The compilers of the directory, completed in 1989, were surprised at the complexity of the rural science system, and, in face of the difficulties of evaluating the efficiency of such a system, advocated no immediate radical changes.

In 1984 a Public Service Board Joint Management Review examined primary industry research schemes. The Review recommended once more the centralisation of the financial control of each scheme with a tightening of the conditions under which grants were awarded.[60] In 1985 the Rural Industries Research Act was introduced to provide greater accountability for the use of research funds by standardising the administration of the existing Rural Industry Research Funds.[61]

Under the Act the Research Comittees for each industry were replaced by Research Councils. The primary objective of the Councils is to increase the

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56 Department of Primary Industry, *Annual Report 1980-81,* pp. 38-53.

57 Australian Labor Party, *Platform, Consitution and Rules as approved by the 35th National Conference, Canberra, 1982,* ALP National Secretariat, Canberra, 1982, pp. 147-154.

58 Jones, 'The 1984 Science and Technology Budget', p. 247.

59 The Bureau therefore included fisheries and forestry research in its directory.
Evans, Swinbank & Williams, 'An introduction to public sector resources allocated to research from the rural industries', p. 10.

60 Public Service Board, *Annual Report 1983-84,* Parl. Paper no. 278, 1984, p. 44.

61 The exceptions were the wool and meat and livestock industries which were in the process of changing to corporate status; and the fishing and wine industries which were undergoing investigations at the time.

commercial returns to the industries by funding research into a wide range of activities involved in rural economic production including production, processing, processing, storage, transport and marketing. In addition the government transformed the Special Research Grant into a new scheme for the funding of rural research falling outside the ambit of the existing Rural Industry Research Funds. The scheme would be administered by an Australian Special Rural Research Council awarding funds provided by the Commonwealth government into the Australian Special Rural Research Fund.[62]

Despite these changes in structure and process the industries and the Commonwealth government were still not satisfied that the research and development being funded by the Research Councils was directed towards those aspects of rural production which would lead to the greatest national commercial benefits. At two major forums debating the funding of rural research the Minister for Primary Industries and Energy, John Kerin, expressed the government's view that, with $500 million being spent on rural research in Australia, it was the government's responsibility to see that efficient and effective funding arrangements were established.[63] For producers and fund managers there was still the perception that the persisting influence of scientists on the direction of research led to over-emphasis on production techniques to the detriment of research into the processing and marketing of commodities. They considered that the process of asserting industry control over research had not gone far enough. The Manager of Research and Promotion for the Australian Wool Corporation said:

> In the past wool production has been excessively influenced by scientists' perceptions of the needs of industry. Expenditure on the development and commercialisation of results has generally been small....I believe that a major issue for the future in rural R&D is the balance between research and the process of development and commercialisation of new technologies arising from R&D.[64]

In a similar vein the Chairman of the National Farmers' Federation spoke of his fellow members concern over the issue:

> In the discussion we have had about the changes taking place in agricultural research it is very clear that many research scientists and administrators are very uncomfortable with the rising trend for control of funds and priorities to rest with non-scientists outside of their organisation. I can offer no comfort on that

62 Australia, Senate 1985, *Debates,* vol. S108, pp. 1598-1601.

63 Hon. John Kerin, Opening Addresses for Bureau of Rural Resources, *Workshop on the Organisation and Funding of Rural Research,* 12-13 May 1988, AGPS, pp. 7-10; and Bureau of Rural Resources, *SCA Workshop on Research Priorities and Resource Allocation for Rural R&D,* AGPS, Canberra 1989, pp. 3-7.

64 Bob Richardson, 'Rural commodity research priorities', in *SCA Workshop on Research Priorities and Resource Allocation for Rural R&D,* AGPS, Canberra, pp. 18-25, p. 24.

score. In fact the NFF considers that the process should be taken even further.[65]

Consequently, in 1989 the process of privatising the administration of the remaining Councils which had not already become corporations was legislated in the Primary Industries and Energy Research and Development Act. The Act effectively allowed the industries greater financial flexibility and commercial control in return for increased accountability through the centralisation of representative selection and reporting requirements. The corporations are allowed to enter into joint ventures, take out patents and licences and raise funds from a range of sources.[66]

Of particular interest is the Rural Industries Research and Development Corporation (RIRDC) which has been established to fund rural research in areas which would otherwise not be funded through market mechanisms. The RIRDC incorporates such previously autonomous small rural research trusts as chicken meat, egg, and honey bee into one overarching corporation which also funds research into potential rural indutries such as cashews, coffee and tea tree. The Corporation sees its role as 'innovative, catalytic and coordinative' in developing Australia's rural industries of the future.[67]

Summary: rural research

For the greater part of the last twenty five years rural industry research in Australia has been organised on an ad hoc, fragmentary basis which saw a proliferation of research organisations undertaking work on behalf of industry funds and State governments. The Hawke government inherited a rural research system which had been intensely investigated but which had undergone only partial restructuring to fit the changing needs of Australian economic production and global trade. The corporatisation of the rural research funds and councils, and the establishment of agencies to inform the funding process have, together with the changes occurring in CSIRO and higher education, demythologised the organisation of rural research. Fundamental to the transition were the processes of prioritisation, evaluation, and selection discussed in the next chapter.

5. CONCLUSION

Control over the organisation of research is one of the fundamental tenets of the ethos of science, which proselytises universal, socio-cultural objectives for both the production and use of the products of research. It was therefore inevitable that, when

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65 John Mackenzie, 'The views of the rural sector', in *Workshop on the Organisation and Funding of Rural Research,* pp. 70-78, p. 72.

66 Australia, House of Representatives, *Debates,* vol. HR 169, 1989, pp. 2463-2473.

67 Australia, Rural Industries Research and Development Corporation, *Annual Report 1990-91,* Parl. Paper 437, Canberra, 1991, p. 3.

govenments began to impose techno-economistic objectives on the science system, scientists would resist all attempts to reduce their organisational autonomy. In Australia the need for governments to change their ideas about science began to be expressed in the attentive public in the 1960s, but it was not until the 1980s that relatively systematic restructuring was attempted. Implementation of the proposed changes required a firm commitment to the principle of government intervention in publicly-funded research.

The Hawke government was elected in 1983 on a platform which included plans to restructure Australian economic production away from dependence on the export of commodities and towards a more science-based economy. Inevitably such restructuring involved the organisation of research and development, and it was resisted by sections of the scientific community in both CSIRO and the higher education system which had hitherto enjoyed considerable autonomy in formulating objectives for research. In order to overcome this resistance ALP governments have had to use a whole armoury of restructuring mechanisms including publicly-funded financial incentives, statutory obligations and the establishment of agencies more open to industry needs and market forces.

Industry too has had to be persuaded to consider research as an investment strategy. Making research institutions more open to industry requires that industry should want to interact in this way. In rural research such interaction had long been insitutionalised but required to be systematically catalogued in order to avoid duplication of resource use. Restructuring in manufacturing industry research had to be achieved on two fronts: by convincing the core executive of the need for a research tax subsidy; and by convincing firms that their long-term survival could be achieved through collectively, as well as individually, funding research and development.

At the heart of this restructuring and its resistance by scientists lies the process of evaluating the worth of research projects. As government assumed greater involvement in directing the organisation of research the processes of evaluation and prioritisation into the selection of research projects came under scrutiny. The next chapter analyses the changes that occurred in this aspect of science policy.

CHAPTER 7

PRIORITISATION, SELECTION AND EVALUATION

The third major change in the ouput of science policy has been in the development of processes of prioritisation, selection and evaluation of publicly-funded research. The most fundamental changes have occurred in the objectives, criteria, processes and agencies of evaluation. Changes in the objectives for research are discussed in chapter three which documented the development of techno-economism as the rationale for allocating public resources to research and development. This chapter concentrates on the way these objectives have been implemented in the science science system. The criteria by which research activity is evaluated have changed from those based on values of scientific excellence to those based on the economic benefits to be derived from investment into research and development.[1] The change has entailed a considerable increase in the level of non-scientific accountability to which government funded or subsidised research activity is subjected. In Australia the activities of the public sector science system have traditionally been evaluated by scientists with minimal input from users, including non scientific government actors. A steady state of resources, and the burgeoning costs of research have resulted in a situation in which managers and subgovernmental program administrators have developed new methods of evaluation which attempt to incorporate elements of both administrative and scientific rationality. The introduction of these methods has caused considerable conflict within the science policy community as scientists have resisted accountability mechanisms which encroach on their traditional freedom from notions of administrative and economic eficiency.

The type of evaluation introduced into the decision-making processes of science have been adapted from those used elsewhere to monitor and evaluate the delivery of goods and services in the public sector. Public and private sector consultants agree that there are three stages to this type of evaluation:

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1 The Bureau of Industry Economics defines evaluation as being the process of facilitating 'better choices' where 'better' means the extent to which activity contributes to the underlying objectives of public policy. Such objectives may be socially or economically defined. A significant objective for many public programs is the maximisation of economic welfare which involves making choices about which projects will make the largest contribution to national economic welfare.
Bureau of Industry Economics, *Evaluation of public sector support for industrial research and development,* AGPS, Canberra, 1986, p. 2.
The ideology of techno-economism in science policy fits this notion of program evaluation. The cultural aspects of science policy cannot be so easily evaluated. For example, how is it possible to assess whether the cultural life of the nation will benefit more from funding certain esoteric aspects of radio astronomy or studying the distribution of flora in the Tarkine Wilderness of Tasmania?

- *ex ante evaluation :* which occurs prior to project selection;
- *concurrent evaluation:* which involves the continuous monitoring of research activity in terms of project objectives;
- *ex post evaluation:* which involves determining whether the project has achieved its stated objectives.[2]

The extent to which these evaluation processes have been introduced is an indication of the political resolve of the subgovernment of science policy to create a research environment in Australia which is centred on the commercialisation of research results. Prioritisation, selection and evaluation have been introduced at different rates, and by different means, in each of the four sectors of the science policy community under examination.

1. Higher Education

Peer evaluation of research in universities has traditionally been part of the basic premise of the autonomy which protects academe from undue political influence. The political ideology of techno-economism requires that the production of new knowledge should be evaluated in terms of economic and social utility. Thus there is a potential conflict of values between the evaluators of research in terms of international competence and academic acclaim, and the evaluators of research in terms of economic and social utility. One of the major changes effected by science policy in recent years has been the superimposition of criteria of utility over the criteria of international scientific competence. This has been achieved by deliberately centralising control of major funding programs outside the higher education subgovernment; by reducing the autonomy of the granting system; and by opening the process of research evaluation to peers outside the higher education system.

1.1. Prioritisation, selection and evaluation in 1965

In 1965 the evaluation of university research was undertaken by two principal mechanisms. Firstly, recurrent and special research grants were distributed to individual universities on the basis of the level of post-graduate activity. Autonomous university research committees then distributed the funds internally according to the priorities of each university. There was little superstructural or subgovernmental intervention in the internal allocation process. In 1966 the University Commission advised research councils that they should not attempt to fund all areas of research in each university. In 1975 the Commission proposed that some co-operation and concentration should occur between universities undertaking the same type of work, but there were no incentives within the funding system to encourage university researchers to interact in this way.

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2 T.G. Parry & P.F. Baxter, 'Evaluation of the Industrial Research and Development Incentives Scheme: A Case Study in Program Evaluation', in *Evaluation of public support for industrial research and development,* Bureau of Industry Economics, AGPS, Canberra, 1986, pp. 57-63.

Secondly, the ARGS grants were awarded on the basis of 'outstanding individual merit' according to the judgement of the ARGS Committee.[3] Funds were distributed to scientists outside Commonwealth or State government research agencies. The grants were made purely on the individual merits of each proposal, and with no consideration of equity of distribution between states or universities, or any prioritisation of disciplines:

> In reaching its decisions the Committee concerned itself only with the quality of the project and of the investigator. The Committee considered that it should not attempt to achieve any preconceived balance of grants as between disciplines and institutions.[4]

Although there were provisions within the terms of reference for ministerial involvement in deciding which proposals were to be supported there no formal evidence that such involvement occurred in the first few years of the scheme.

1.2. The introduction of prioritisation

In 1972 Fraser, as Minister for Education and Science in the McMahon government, designated 15 per cent of ARGS funds into four specified areas of research: upper atmosphere science, the acquisition of a nuclear resonance spectrometer, the vaguely-worded 'multi-disciplinary research' and marine science. The Queen's Fellowship Scheme dating from 1970 was also earmarked for research into marine science and the Queen Elizabeth II Fellowships, dating from 1964 and designated at that time for physical and biological science, were also the responsibility of the Department. Each scheme had separate advisory and granting committees.

In 1975 the ARGC reasserted its policies of supporting excellence rather than priority disciplines:

> The Committee has consistently sought to direct itself to supporting the most outstanding and promising research being carried out in universities and research institutions. This has had the effect of striking some balance between the disciplines in ensuring that the most outstanding work in each discipline is supported. However, if work of sufficient merit in a particular discipline is not offered, the Committee has resisted the pressure to allocate money for second-rate work.[5]

The policy was endorsed by the 1978 ASTEC Report which called for a higher and stable level of funding for the ARGS scheme and the maintenance of the 1974 level of recurrent grants (and therefore the 'block' special research grants) in real terms.[6] ASTEC further endorsed the system in 1979, recommending that the process of allocation and evaluation should not be changed except insofar as:

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3 The Committee consisted of nine professors and a Chair: Professor R.N. Robertson, a botanist from Adelaide University and President of ANZAAS.
Australian Research Grants Committee, *First Report,* Parl Paper, p. 571.

4 Ibid., pp. 1-2.

5 Australian Research Grants Committee, *Report 1973-75,* p. 3.

6 ASTEC, *Science and Technology in Australia, 1977-78,* vol. 1A, AGPS, 1978, p. 5.

> ASTEC recommends that universities re-examine their procedures for the distribution of research funds derived from the Recurrent Grants and the Special Research Grants with a view to giving greater support to their best research workers, and, when appropriate, to group and team efforts.[7]

However, there should be no selection according to any other priority than the traditional one of excellence:

> ASTEC believes that excellence in research needs to be supported irrespective of any immediate or perceived social, economic or other benefit.[8]

In 1983 the process of selection for grants had remained virtually unchanged since 1972 and consisted of the following elements:[9]

- applications, called for in February of any year were first seen by the full Committee in April;
- an Executive Committee of the full Committee then divided the applications for examination by sub-committees according to discipline;
- the sub-committees appointed panels and assessors for each project;
- reports from the assessors and panels were read by the full Committee in June;
- interviews were arranged with the applicants whose projects required further clarification;
- the Committee made its final recommendations which were sent for ministerial approval;
- the successful applicants were announced in October of each year.

The Committee, which was still evaluating projects on grounds of academic excellence alone, was accountable to a new government and a Minister for Science and Technology who envisaged a far more proactive role for the grants scheme in advising the government on areas of research with the greatest socio-economic benefit to Australian society.[10] The resulting clash of values was reflected in statements made in the Committee's Reports for 1984 to 1986. In 1984 the Committee absolved itself of the responsibility of discrimination between 'subject areas' as well as between States and institutions. However, the Committee felt that it could include evaluation and reporting of areas of research strength within its role, but expressed yet again its central criterion of excellence:

> It is no exaggeration to say that the development of many new Australian initiatives in commercial application... are possible because the ARGS has in the past supported many excellent proposals in Universities.[11]

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7 ASTEC, *The Direct Funding of Basic Research,* AGPS, Canberra, 1978, p. 67.

8 Ibid..

9 In 1968 the Committee introduced a process of evaluation of projects which had been funded for three years in order to assess the success of the project and whether funding should be continued. The grantee was required to submit a progress report which was evaluated by assessors appointed by the Committee. Publications arising from the project were used as an indicator of success. In 1975 a further evaluation was introduced for projects which had been funded continuously for six years. Grantees were required to submit for subsequent grants *ab initio* applications which would undergo the same selection processes as first-time applications.

10 Jones, 'Government funding of scientific research', p. 8.

11 Australian Research Grants Committee, *Report on Grants Approved for 1984,* pp. 6-7.

In the following year the Committee felt obliged to clarify that its area of concern was with 'outstanding and promising research' which should lead to the publication of results and that the *development* of scientific knowledge to the stage of patentable products or processes was beyond its purview and resources. Neither would the Committee favour teams rather than individual researchers.[12] This obvious reluctance to change led the government to ask ASTEC to review the functions of the ARGC.

1.3. Excellence and selectivity

In 1987 ASTEC endorsed the government's changed expectations of university research, finding that existing granting procedures in higher education were 'limiting the sector's research performance' in providing the 'research base upon which Australia's future industrial performance will increasingly depend'.[13] In the 1987 Report, which ASTEC claimed was based on extensive consultation with all sectors of the scientific community,[14] ASTEC recommended that the basic premises upon which the new council would distribute its funds should encompass not only excellence but also accountability and relevance:

> While basic research is motivated primarily by curiosity in the selection of topics and the conduct of research, we do not consider it relieves individual researchers or their institutions of the requirement to be accountable to the public for the support which is provided for research. We see no conflict between the pursuit of excellence in research and the relevance of that research to important economic or social issues.[15]

ASTEC also recommended that the primary objective of research in higher education institutions should be its contribution to national economic and social objectives: the advancement of fundamental scientific knowledge was considered secondary.[16] To this end ASTEC suggested that the role of a new council should be expanded to include: '...the identification and selective support of emerging or undeveloped fields of research which are likely to be important in the national interest...'.[17] This recommendation was taken up by the government and written into

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12 Australian Research Grants Committee, *Report on Grants Approved for 1985,* p. 2.

13 ASTEC, *Improving the Research Performance of Australia's Universities and Other Higher Education Institutions*, AGPS, Canberra, 1987, p. iii.

14 Associate Professor Ian Lowe of Griffith University disagrees. He considers that ASTEC decided in advance of consultations what their recommendations would be. He says:

> When ASTEC came here to air their views when they were partway through their studies on higher education funding they weren't really interested in consulting people but in propounding their views which were that you need to concentrate funds to achieve critical mass and support the best researchers. Their view was that the reason we in Australia lag behind other countries is that we are a small country and we can't afford to research across the board. We have to concentrate resources on the best workers.

Interview, 1.11.89.

15 ASTEC, *Improving the Research Performance of Australia's Universities and other Higher Education Institutions,* p. 2.

16 Ibid., p. 6.

17 Ibid., p. 36.

the enabling legislation for the Australian Research Council (ARC).[18] It was repeated in the terms of reference in two clauses which required the Council to advise the government, through NBEET, on the formulation of research policy relating to:

- the support to be given to fundamental research and to research that will contribute directly to the economic or social development of Australia;
- measures aimed at improving interaction among the higher education sector, the private research sector and the industrial sector;...[19]

The ARC has control of a large proportion of the resources allocated to higher education research. Among the major programs are the ARC Grants Program, the Special Research Centres Program, the Key Centres of Teaching and Research Program, the Research Fellowships Scheme and the Queen Elizabeth II Fellowships Program. Most of these now have at least one criterion of relevance to national socio-economic interests which must be fulfilled. Table 7.1 lists the broad objectives of the major schemes.

Table 7.1: The objectives of ARC funding schemes in 1990

ARC Grants:	are awarded on the likelihood of the project's making a real advance in knowledge, either by making a significant contribution to understanding or by making a contribution to the solution of an important practical problem.
Special Research Centres:	are intended to support outstanding research in fields that will contribute substantially to Australia's development and in which Australia has gained international recognition.
Key Centres of Teaching and Research:	combine teaching and research activities and are closely linked to the needs of industry and commerce.
ARC Research Fellowships:	are awarded on criteria of (among others) • relevance to priority areas of national interest; • the likelihood of producing benefits to Australian industry.

Data source: Department of Employment, Education and Training, *The Australian Research Council Awards 1989,* AGPS, Canberra, 1989, pp. 10-13.

The new general criteria are applied within a two-tier selection and evaluation system of peer review which is basically the same process as that refined over many years in

18 The ARC is directly responsible both to the National Board of Employment, Education and Training (NBEET) and only indirectly to the Minister for Education rather than the Minister for Science. The ARC has a more formal structure; an envelope of funds bolstered by research funds previously allocated to the universities as part of recurrent grants, and a more explicit set of mission statements emphasising the contribution that scientific research can make to the nation's socio-economic wellbeing rather than merely the pursuit of excellence. The new Council has ten members, two of whom sit on NBEET. This arrangement replaces the previous informal consultation with CTEC to avoid duplication of award recipients.
ARC, *The Australian Research Council Awards 1990,* pp. 1-5.

19 ARC, *The Australian Research Council Awards 1989,* AGPS, Canberra, p. 15.

the ARGC grants scheme.[20] In addition the ARC is developing strategies to evaluate the quality of research across the entire spectrum of its programs. These will consist of internal reports by the Chairmen of discipline panels, and external reports of fields of research to which large amounts of funds have been allocated.[21]

Another aspect of research evaluation in higher education which is in transition is the redistribution of the research component of recurrent funds for higher education institutions. In 1991 a working party from the ARC, DEET and the Higher Education Council (HEC) were in the process of formulating a 'composite research funding index' for future allocations of this money.[22]

1.4. A wider spectrum of decision-makers

As well as broadening the criteria of selection, successive governments have widened the spectrum of social interests represented on the various committees and councils which make the most important decisions in the allocation of resources within the higher education research system.[23] Similar changes are evident in the composition of the Co-operative Research Centres Committee in comparison with the Steering Committee to Review Commonwealth Special Research Centres. The CRC Committee formed in 1990 has a third of its members from outside the higher education system whereas in 1986 only a sixth of the members of Special Research Centres Assessment Panels were non-academics and two-thirds of these were from CSIRO.[24]

The most significant change is in the composition of the ARC and its various committees. Until 1975 the ARGC and the pool of experts upon which it called for assessment were composed almost entirely of academics with the one exception of a CSIRO scientist. In 1990 one third of the ARC members are non-academics and almost every committee has at least one non-academic member. The Planning and Review Committee had equal representation of non-academics, and the Institutional Grants Committee was chaired by the Chief Science Adviser of DITAC (now the Department of Industry, Technology and Regional Development). Such external representation brings to the processes of prioritisation, selection and evaluation a wider set of expectations of the research outcome of higher education.[25]

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20 Geoff Wilson, 'Research funding best served by peer review', *Australian,* February 13, 1991, p. 16.

21 Department of Education, Employment and Training, *Higher Education: Quality and Diversity in the 1990s,* Policy Statement by the Hon. Peter Baldwin, MP, Minister for Higher Education and Employment Services, AGPS, Canberra, 1991, p. 35.

22 The community also requested that the means of allocation of the funds should be as simple as possible.
The Australian Research Council Awards 1990, pp. 14-15.

23 Commonwealth Tertiary Education Committee, *Commonwealth Research Training Centres and the Future of the Program,* Attachment B.

24 Department of the Prime Minister and Cabinet, *Co-operative Research Centres Program,* p. 25.

25 Ibid., pp. 33-42.
ARGC, *Report 1973-75,* pp. 1-3.
Australian Universities Commission, *Third Report 1964-69,* Appendix 1.

1.5. Summary: evaluation in the higher education research system

In analysing the extent and impact of the changes in evaluation processes for the allocation of resources to research in higher education it is useful to examine the impact of changing science policy at three levels. At the micro-level of individual projects the criteria of selection have been broadened from traditional academic criteria of excellence to include explicit notions of contribution to national economic welfare. At the meso-level of the allocation of resources to institutions there has been a loss of autonomy, due in large part to the general failure of universities to concentrate their areas of research and co-operate in the use of research facilities, and a corresponding increase in the formalisation of selection processes. At the macro-level of the interaction of the institutions of higher education with other societal agencies there has been an apparent loss of autonomy in the increased accountability of the ARC, the Higher Education Council and NBEET to departmental and ministerial control.[26] However, the potential for political control and intervention has always been written into legislation and terms of reference. What changed in the mid 1980s was the political will to enforce upon the higher education research system increased accountability for public funds according to criteria which embraced a wider definition of economic and social benefits than had hitherto been expected of an evaluation system informed by scientific norms and values.

2. CSIRO: Scientific Norms to Multiple Rationality

In the mid-1960s the process of evaluation of any public policy was relatively undeveloped. This was particularly so in science policy where governments were only just beginning to come to terms with the idea that the internal allocation of public sector science funding could not be left to the scientists. The need to evaluate CSIRO research programs occurred as research budgets ceased to be open-ended, as the cost of research increased with the complexity and number of fields of science, and as research became more important in economic growth. The problem has been the choice of criteria used in the process of calculating the costs and benefits of alternative programs. Governments had to impose techno-economic objectives onto selection

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National Board of Employment, Education and Training, *Annual Report 1990-91,* Parl. Paper 267,Canbera, pp. 80-81.

26 Accounts of the extent of this interference in the allocation of resources vary. Professor Wilson, Chairman of the Research Grants Committee of the ARC declares that there has been very little ministerial influence on either the areas of research to be given priority or on the aarding of individual grants. Professor Wilson says that more pressure comes from scientists than from public servants or politicians. On the other hand, reports of ARC meeting documents sent to *The Australian* newspaper claim that, in 1990, the Minister for Education relayed to the ARC Cabinet's wishes that a research centre in a certain area of health care should be established. Professor Wilson was purportedly present at the meeting. The problem seems to lie in academics' notion of autonomy as absolute rather than relative to the enabling legislation or the terms of reference of the ARC.

Wilson, 'Research funding best served by peer review', p. 16.

William West, 'Politics "at play" in research centre', *Australian,* November 7 1991, p. 11.

processes traditionally controlled by scientists using criteria more suited to nationalistic-cultural objectives.

2.1. Evaluation in 1965

In 1965 CSIRO used two 'equally important' criteria for deciding which projects were to be undertaken. Firstly, as prescribed in the Science and Industry Research Act 1949, a project must be likely to yield benefits to primary or secondary industry. Secondly, projects were decided according to whether or not there is a scientist in the organisation with 'original and bright' ideas about the research to be done. Thirdly, and only if the other two criteria were met, it may be possible to catalogue areas 'of economic or practical importance' which would yield benefits.[27] Scientists should decide which areas of manufacturing were suitable for research since:

> In my experience, scientists are rather more capable than industrialists of perceiving from their knowledge of both science and industry the points where the most successful attack may be launched.[28]

It was the function of the CSIRO Executive to make a 'reasoned judgement' as to whether a project was worth supporting in the long-term in terms of practical application of the results.[29] The Executive decided which work was 'misdirected or unproductive' or which had failed to reach its full potential. Considerable emphasis was placed on selecting 'the right man' because the philosophy of research management in CSIRO was that the degree of control needed is inversely proportional to the research capability of the staff. Less capable staff need greater direction.[30] As much attention seems to have been paid to monitoring the development and needs of individual researchers as of the projects themselves.

Gillespie (a CSIRO administrator) gives a similar account of the process of evaluation in CSIRO in the mid-1960s. The Executive selected the broad areas of research in relation to national economic need. The Chief refined these broad areas into more specific fields of research within divisional responsibility. The researcher was then: '...encouraged to select from these fields those problems which are the most important'.[31]

However, Peres (also then a CSIRO administrator), speaking to the Harvard Graduate School of Public Administration, reported that individual scientists had retained considerable autonomy:

> Within the exceedingly broad definition of a Division's or a Section's mission, the determination of scientific programmes is left with that Division or Section. The predominant emphasis is that programme determination rests with individual research workers....at no point in the allocation process within the

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27 White, 'Administrative Problems in the Development of Scientific Research', pp. 113-140.
28 White, 'The Strategy of Australian Science', p. 194.
29 White, 'Administrative Problems in the Development of Scientific Research', p. 120.
30 Gillespie, 'Research Management in the CSIRO', p. 23.
31 Ibid., pp. 21-23.

> Organization is a decision taken by a non-scientist; available funds are distributed in accordance with the judgement of scientists.[32]

Accountability between the Executive and the scientists was minimal. According to Peres, the function of the CSIRO Executive was not to set goals and policies but:

> '...to *stop* goals and policies being imposed on individual research workers'. ...If it were to concentrate on policy planning and lay down policies and programmes the Organization would lose one of its most important attractions, this being the opportunity that individual scientists have of determining their own research programmes. Far from reflecting administrative inefficiency the CSIRO Executive's activities seem a rational recognition of its proper role in a research organization.[33]

This autonomous management style is also reflected in the fact that, although CSIRO introduced program budgeting in the late 1960s, until 1973 divisional participation was voluntary. If divisional chiefs decided not to join the system there was no compulsion for them to do so.[34]

This lack of accountability for the activity of the researcher, the divisional chief and the Chairman was also evident in the articulation between the science system and political system through the relationship between the Executive and the Minister. This was, according to Peres, carried out on the basis of the 'old boy' system with its reliance upon trust in the 'calibre and integrity of the Executive to bring forward those matters that intrude on public policy'.[35] Nowhere in Peres' account, is there a recognition that research projects should be discontinued for any other than scientific reasons. This attitude no doubt stems from the fact that, in the mid-1960s:

> Although the Executive and associated advisory committees devote some time to persuading the Cabinet, through the Minister and the Treasury, to endorse its annual proposals, finance is not a severely limiting factor....The comparative abundance of money has meant the Organization has not been restricted greatly in its ability to provide research workers with the equipment and materials necessary to pursue investigations.[36]

In those days it was the lack of human resources in the form of scientists which curtailed the researchers' plans and from this stemmed the lack of political control through administrative accountability and the fact that scientific norms were used in evaluation rather than economic or political rationalism. Australian governments needed scientists more than scientists needed government. The autonomy norms of the science system could be upheld and held up in later years as the normal way of

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32 Leon Peres, 'Research Organization and the Control of Incentives: The Case of an Australian Scientific Organization', *Public Administration,* (Sydney), vol. XXII, no. 4, December 1963, pp. 330-349, p. 332.

33 Ibid., p. 347.

34 J.S. Marsden et. al., *Returns on Australian Agricultural Research,* CSIRO, Melbourne, 1980, p. 15.

35 Peres, 'Research Organization and the Control of Incentives', p. 336.

36 Ibid., p. 345.

evaluating research. The policy was rational to scientists because theirs was the prevailing ideology.

2.2. Research evaluation in 1990

In 1990 the process of evaluation in CSIRO has shifted from one based on choice exercised by individual researchers to one based on a systematic process of collective corporate choice. The moves towards increased accountability did not come from within the Organisation but from changing perceptions within the subgovernment and the attentive public (particularly Parliament) that public sector funding for research and development was inadequately monitored. The process began with the 1986 amendment to the Science and Industry Act and was continued with the Joint Committee of Public Accounts Inquiry into Public Sector Research and Development and the Australian National Audit Office's Efficiency Audit into CSIRO's External Funds Generation.

The 1986 Science and Industry Act laid the foundations for a new form of accountability in CSIRO by repealing the traditional annual report requirement of the 1949 Act and relacing it with a three-stage process of reporting.[37] Firstly, the Act determined that the Board should declare a 'planning period' of not more than 5 years during which a strategic plan must be formulated and implemented. Secondly, the strategic plan had to outline not only objectives, and strategies for their achievement, but also mechanisms for their review and revision and a prohibition on organisational 'functions' not included in the strategic plan. Thirdly, the Board had to approve annual operational plans subject to similar review and revision practices.

These requirements were operationalised in CSIRO by the development of a system of research priority selection and actively encouraged by the first Chief Executive (Stocker) with extensive experience in commercial research. At the Organisational level this process is implemented by the Chief Executive and six Institute Directors of CSIRO with the 'active involvement' of Board members.[38] Research purposes in CSIRO are classified according to a modified version of the Australian Bureau of Statistics' national research classification approach which has seventeen sub-divisions of research purposes.[39] For each of these research purposes

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[37] Science and Industry Research Act, no. 13 of 1949, Part VII (Miscellaneous); Science and Industry Research Legislation Amendment Act, no. 121 of 1986, Part VII (Strategic Plans and Annual Operational Plans).

[38] John W. Stocker, 'CSIRO on the move', *Science and Technology Creating Wealth for Australia,* NSTAG 1990 Forum Report, pp. 31-40, p. 32.

[39] They are:

- plant production and primary products
- animal production and primary products
- rural-based manufacturing
- minerals industry
- energy resource industry
- energy supply
- manufacturing industries
- information and communication industries
- transport
- construction
- environment
- economic devlopment. - environment aspects
- health
- defence
- social development
- commercial services

key data have been gathered on such issues as gross value of production, imports, exports, value-added, research expenditure, major performers of research, and research intensity. Four broad criteria for assessing the return on research and development have been developed from criteria used by the Industrial Research Institute of the USA. They are:

1. the *potential* economic, social and environmental *benefits* possible from technological improvements resulting from the research;

2. Australia's ability to *capture* the benefits by conversion to commercial products or processes;

3. the *research and development potential* of relevant research areas;

4. the *research and development capacity* of relevant research areas, i.e., Australia's capacity to conduct both the research and the development which ensues.

Each research purpose and criterion combination is given a score by each group participant. Criteria 1 and 2 are then multiplied to give a measure of 'attractiveness' and criteria 3 and 4 to give a measure of 'feasibility' on the likely returns to Australia of investing in a particular area of research. Attractiveness is therefore the product of potential benefits and Australia's capacity to maximise the benefits, and is considered external to CSIRO's capacity to influence. Feasibility is the product of research and development potential and capacity and is a measure of the ability to achieve technical progress in Australia. Here there is some measure of control by the research organisation. Discussion and iteration allow scores to be averaged across the group. The analysis is used to decide the level of support that CSIRO should provide for each purpose.[40]

The analysis is also used in the review process through annual monitoring of divisional and sub-divisional spending expenditure and other resource allocation. Guidelines based on the classification are issued to research managers who are expected to allocate resources accordingly.[41] The first *Operational Plan* was published in 1991 and set out for each division:

• advancement of knowledge

40 Ibid., p. 34.
The CSIRO model has also been approved by the Joint Committee on Public Accounts which recommended that the model be used by the Government to set national research priorities and by other research agencies to assess internal priorities. Australia, Joint Committee of Public Accounts Inquiry into Public Sector Research and Development, p. 128.

41 Australia, *CSIRO Annual Report 1990-91*, p. 134.

• the divisional objective;
• the intended strategy;
• specific objectives with the proportion of resources allocated to each;
• the planned outcomes of specific objectives;
• the total appropriation allocation;
• the amount of sponsored research to be undertaken;
• the expected proportion of externally-generated funds.[42]

Some divisions have introduced additional processes of evaluation. For example, since 1988, research projects in the Division of Chemicals and Polymers, have been evaluated from two different perspectives, that of 'business area' and that of 'science and technology'. This has meant the closure of some projects which were judged inadequate either in terms of their commercialisation potential or that expenditure on that particular aspect of strategic science could not be justified in terms of excellence foregone in other areas.[43]

The Division of Wildlife and Ecology has been developing over five years a system of research evaluation which addresses the question of how to allocate funds to scientists of different abilities in order to maximise results. In the scheme each scientist is given a research accountability score comprising scientific publications, research effect and contribution to science management and communication. The research effect component is measured by the influence of the individual's work on both social and national interest objectives and on the scientific discipline. Projects are budgeted on the basis of the scores of the researchers working on the project. The application of the scheme has had dramatic positive effects on the careers of some scientists whose contributions had been hidden behind the politics of internal budgeting and negative effects on others whose poor contribution had been similarly hidden. Many of these have left the Organisation.[44]

2.3 Summary: evaluation in CSIRO

The process of evaluation in CSIRO remained stubbornly science-based from 1949 until 1986. Change did not occur until policy-makers with a techno-economistic ideology of international economic competitiveness, based on an expanded rate of innovation, became powerful enough to withstand the political influence and organisational inertia of scientists. Change was effected by a combination of organisational restructuring, legislative amendment and financial stringency/ incentives. Within the Organisation new processes of prioitisation, selection and

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42 CSIRO, *Australia's Science: Australia's Future,* CSIRO Operational Plan 1991-92.

43 The Division Advisory Committee, consisting of eight private and two public representatives of user groups are involved in the process of project evaluation at the annual strategic level to ensure that criteria of relevance are used in the process and that the Division pursues only those projects for which there are Australian companies capable of commercialisation. Joint Management Committees are also set up with industrial partners (such as Du Pont or Kodak) which participate in the evaluation of pre-competitive stages of research.
CSIRO, Division of Chemicals and Polymers, *Research Report 1988 and 1989,* CSIRO, 1990, pp. 1-4.

44 B.H. Walker, 'Assessing Scientific Performance', *Search,* vol. 22, no. 2, March 1991, pp. 62-64.

evaluation were introduced by scientists appointed by the subgovernment for commercial as well as scientific success. Scientists in CSIRO now have to organise their creativity in line with commercial, economic and political criteria as well as those of scientific competence.[45]

3. MANUFACTURING INDUSTRY

Objectives of economic benefit are implicit in the *raison d' etre* of economic production. The issue for governments in Australia has been to encourage firms to incoporate science-based innovation into their management of economic production. In 1965 the choice of research area to be subsidised was left to individual firms. Increasing concern about the need to restructure economic production away from reliance on commodities has led to selection processes based on the notion that governments have the right to prioritise the areas of manufacturing research funded by public resources.

3.1. Selection process and criteria in 1967

In 1967 the process of evaluation for industrial research and development grants involved what Lamberton called 'a narrow approach to a major problem'.[46] The major problem was the low domestically-generated knowledge base of non-rural production in Australia. The narrow approach was the definition of research and development and the assumption that increasing private expenditure on the production of scientific knowledge would automatically lead to commercialistion of that knowledge. The evaluation process for the allocation of grants was based solely on whether the activities proposed by the grant applicants fitted the activities defined as research and development by the Industrial Research and Development Grants Act. The Board of three members decided which firms were eligible under the Act.

The process of evaluation was different for the two types of grant, but the difference between the grants was only that of size. For companies which increased the research and development expenditure by up to $50,000 the evaluation process was virtually non-existent and grants were awarded semi-automatically on a dollar for dollar basis.[47] Beyond this amount the grants became selective and could require Ministerial approval. As would be expected the criteria on which the awards were to

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[45] An example of the changing nature of priorities is given in the account by the Assistant Chief of the Division of Wildlife and Ecology of how a project of international scientific significance, that of the effects of the environment on the pineal gland of marsupials, was abandoned in favour of one examining the way in which viruses can be manipulated to cause infertility in vertebrate pests such as rabbits. Both projects were of equal scientific excellence but the scientists decided that the applied nature of the rabbit research was more urgent. The motivating force was that the second program would definitely attract external funding but the first would not. The leader of the research expressed surprise at how exciting the process of applied research could be. Hugh Tyndale-Biscoe, 'Priority Rules, OK!', *CoResearch,* no. 341, June 1991, p. 4.

[46] Lamberton, *Science, Technology and the Australian Economy,* p. 66.

[47] Stubbs, *Innovation and Research,* p. 188.

be made were almost unequivocally to do with national economic interest (the relevance of the fifth criterion is oblique).

- the development and use of Australian resources;
- the expansion of exports;
- import saving and improvement of the ability of Australian products to compete with imported products;
- the improvement of productivity and reduction of costs in Australian industry; and
- the development of the Australian economy in a manner conducive to the defence of the Commonwealth.[48]

For the first two years of operation funds were available for all applicants who passed the eligibility tests. By the third year the Board were having to decide which firms were able to meet a higher proportion of their increased expenditure on research and development and which merited the full grant allocation. Priority was given to those projects which would decrease the amount of imported technology and overseas licence and royalty payments.[49]

In addition to these criteria there were provisions that firms would be eligible only if they had produced goods in the last twelve months and if the research was to be undertaken by full-time scientific staff. There were also conditions which restricted the eligible use of plant and buildings to research and development activities. These constraints favoured allocation of the grants to firms which could afford full time staff, full-time research laboratories, and which already had a history of innovative activity through research and development.

Eventually even the flexibility of the Board's interpretation of the Act could not cope with increasing demand and the Australian Industrial Research and Development Grants Scheme was replaced by the Australian Industrial Research and Development Incentives Scheme (AIRDIS) in 1976.

3.2 Widening the scope of selection criteria

The new grants were introduced under legislation which limited the life of the scheme to five years after which the scheme itself would be evaluated.[50] The Board was assisted in the selection process by a staff of thirty which, for the first time, included scientists and technologists to assess the merits of the research proposed. Previously

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48 Ibid., section 27 of the Industrial Research and Development Grants Act 1967, given in Appendix G, pp. 248-265.

49 Australian Industrial Research and Development Grants Board, *Annual Report 1969-70,* Parl. Paper 126, Canberra, 1970, p. 4.

50 The three new types of grant were designed to stimulate research and development activity in a wider range of companies. *Commencement grants* allowed firms which had not previously undertaken research and development up to 25 per cent of the eligible expenditure of the company in that grant year, or $15,000. *Project grants* allowed firms already performing reseach and development up to 25 per cent of the amount that, in the Board's opinion, will be the company's expenditure on a project subsequent to the date of agreement. The maximum project grant was $250,000 unless approved otherwise by the Minister.
AIRDIB, *Annual Report 1977-78,* Parl. Paper 308, Canbera, 1978, pp. 4-5.

grants had been denied purely on the basis of non-eligibility according to the Act. Now the criteria became more selective and, unlike the former scheme, were given in a specific Ministerial direction as:

> • the technical and commercial merits of the project including its likely contribution to improvements in industry efficiency and in utilisation of resources, particularly Australian resources;
> • the capabilities and resources of the company to undertake, or have undertaken, the research and development work necessary
> • the ability of the company to exploit commercially the results of the project; and
> • the need by the company for the provision of Commonwealth financial assistance to permit the necessary research and development work and the commercial exploitation of the project to proceed at a satisfactory level and within a reasonable period of time.[51]

These selection criteria for the new grants required the Board to investigate not only the research and development activities of a firm but also its capacity to market products and processes which incorporated the results of the subsidised research.

Commencement and project grants were largely improvements on the grants under the original scheme. Selection for these grants still relied upon a Board of five part-time members assisted by a Technical Standing Committee of three part-time members. The third type of grants - public interest projects - allowed the Minister to authorise the Board to make arrangements for the carrying out of specific projects of industrial research which the Minister determines to be in the public interest:

> Where the Minister is satisfied that it is in the public interest that the Commonwealth should undertake a project of industrial research in a field of science or technology he may authorize the Board to make arrangements, on behalf of the Commonwealth, for the carrying out of that project.[52]

By introducing these grants the government was acknowledging that decisions about what type of manufacturing industry should exist in Australia could not be left to the vagaries of the market: there were some areas of economic production which needed more proactive policies than protection through tariffs and subsidies or being left to the dynamics of market forces. For the first three years public interest grants were awarded on the recommendation to the Board of the Minister. No criteria for the evaluation of public interest projects were issued until 1981. Projects were evaluated according to an unofficial set of guidelines drawn up by an Interdepartmental Interim IR&D Advisory Committee. The 1981 amendments to the legislation reformed the Advisory Committee with the specific function of examining public interest research grant proposals.[53]

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51 Ministerial direction issued 5 April 1977 and quoted in Australian Industrial Research and Development Incentives Board, *Annual Report 1980-81*, p. 7.

52 Industrial Research and Development Incentives Act no. 85 of 1976.

53 John Ryan, 'Evaluation of Public Interest Industrial Research and Development Program', in *Evaluation of public support for industrial research and development*, Bureau of Industry Economics, AGPS, Canberra, 1986, pp. 39-54, p. 45.

In 1981 the effectiveness of the AIRDIS scheme was reviewed in accordance with the 1976 Act. The report of the evaluation process highlights the fact that retrospective evaluations of effectiveness were not included as part of the normal granting process. For example, in 1981 when 1173 commencement agreements were in force, the Board authorised a 'one-off' detailed analysis of only thirty agreements as part of a submission to an IAC inquiry. This single analysis was used for the five-year statutory evaluation.[54]

3.3 The introduction of socio-economic and management criteria

In 1983 the ALP government set criteria of allocation which were far more explicit and detailed than previous criteria. The Board was instructed that:

> ... it is the Government's desire that emphasis be given to the timely support of projects undertaken by companies which show sound entrepreneurial management and regard themselves as servicing a global rather than an Australian market.[55]

In so doing the Board was to use economic as well as technical and commercial criteria and to consider their decisions in the light of the government's overall industry policy objectives. In addition to employing criteria similar to previous ministerial directions the government directed the Board to consider a wide range of socio-economic factors in their selection process:

- the likely benefits to accrue to other businesses and industries;
- the potential impact of knowledge gained and employment generation or cost reduction;
- the extent to which prospective benefits from the project will accrue to Australians and provide national returns beyond the company undertaking the project;
- the level and quality of the industrial research and development, including the use of expertise obtained under the contract;
- the commitment of the applicant to the program;
- the reliance on foreign technology and the availability and cost of accessing that technology.
- the capability of the applicant to see the project through to commercial reality;
- the commercial risk associated with the project.[56]

These criteria explicitly required the Board to assess applicants not only in terms of the potential economic benefits of the application of the results of the subsidised research but also to consider the broader social and economic ramifications of such application and to assess whether these potential effects fitted stated government policies in other policy arenas.

Ryan acknowledges that in defining program criteria there is an inherent tension between the need for flexibility and the need for accountability.

54 AIRDIB, *Annual Report 1981-82,* pp. iii-iv & 17.

55 AIRDIB, *Annual Report 1983-84,* p. 59.

56 Ibid., p. 60.

Despite these changes the AIRDIS scheme was considered too inflexible to accommodate the government's policy on re-structuring Australian manufacturing industry. The government instigated three reviews of the scheme which reported that existing machinery was inadequate for the complexity of allocatory and evaluation processes which were now expected of it.[57]

In 1986 new legislation established the GIRD scheme which has two major components: discretionary grants and generic grants. At the same time a 150 per cent tax concession on research and development was introduced. The evaluation of applicants for the tax concession is conducted jointly between the IR&D Board and the Tax Commissioner, and is concerned with the legitimation of the activity claimed by firms to be research and development.

For discretionary grants the Board, through delegated authority to the Discretionary Grants Committee, must consider each application in the context of: '... the Commonwealth government's industry development policy objectives, including its specific wish to assist small, start-up companies wanting to enter the international marketplace and companies involved in industry restructuring...'.[58] Similarly, the criteria for evaluation of applicants for generic grants explicitly require the Board to consider aspects of the private sector management of research and development which would not formerly have been considered part of the responsibility of the Board. In addition to the socio-economic objectives stated for the tax concession and discretionary grants the Board should ensure that:

- the project fosters closer *collaboration* between research institutions, including those in academe and industry;
- it gives priority to the project if it involves an area of technology with respect to which the Minister has given a direction under section 20 of the Act declaring it to be a *priority area*;
- it considers the extent of *industry commitment* to the project;
- it inquires into the degree of proposed *dissemination of the results* of the projects;
- the *quality of the research* to be undertaken is such that there is a strong probability that it will lead to important new discoveries, the solution of technical problems or the introduction of innovative new techniques in Australian industry;
- it is satisfied about the *ability of the researcher* to undertake the project and achieve goals set out in a clearly defined project management plan; and
- the *experience and record* of the researcher in research and development in the *relevant area* of technology is proven.[59] [italics added]

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57 The three were: an internal review by the Board which included a nation-wide survey on user needs; an examination by Price Waterhouse on the effectiveness of the scheme in promoting industrial research and development; and a report by the Bureau of Industry Economics on the effectiveness of the public interest research program.
AIRDIB, *Annual Report 1984-85,* Parl. Paper no. 431 of 1985, p. iii.

58 Industry Research and Development Board, *Annual Report 1986-87,* Parl. Paper no. 74 of 1988, p. 54.

59 Ibid., p. 56.

The Board has adopted a 'corporate approach' to the process of evaluation which it sees as essential in deciding where in the innovation cycle public money should be used to fund private research and development.[60] The approach was developed by examining the experiences of firms using AIRDIS grants and asking what the impediments to success were. The Board says that there are two types of criteria which are essential for the effective use of such grants. Firstly, *market-oriented* criteria ask two essential questions:

- does the company have strong customer relations in the business area (particularly with leading edge customers)?
- is the company in a strong competitive position in this business?

Positive answers to these questions show that the applicant has a realistic view of the market and customer requirements and has already acquired a considerable market share or good access to the market. Secondly, *project -oriented* criteria require three questions to be asked:

- is the project for an existing company business?
- does the company have research and development experience in this field?
- how substantial is the commercial innovation required?

Applicants who can answer these questions positively are judged by the Board to have a good understanding of the relationship between research and development activity and commercialisation. They are also more likely to be aware of the effect on potential market success of the impact of input prices and competitors.[61] The Board now sees its role as one of fostering the transfer of knowledge from those companies which are successful to those which are starting to use research as a means to innovation. The Board sees the marketplace as the ultimate evaluator and the government's role in the process should be to facilitate networking between experienced and inexperienced firms, particularly in the area of setting up commercialisation teams at an early stage in the identification of research which is likely to yield marketable products and processes.[62]

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60 Industry Research and Development Board, *Annual Report 1990-91,* p. 13.

61 Australia, Joint Committee of Public Accounts*Inquiry into Public Sector Research and Development,* Submissions and Incorporated Documents, p. S1484.

62 Ibid., pp. S1486-87.

3.4 Summary: evaluation in manufacturing industry research

These prioritisation, selection and evaluation processes are now considered part of manufacturing science policy. The operationalisation of the processes involves widening the range of expertise involved in the evaluation process and the consequent diminishing of scientific autonomy. The tax concession allows individual firms to select the direction of subsidised research. Sir Frederick White's assertion of scientists' unique capacity to decide the direction of research has been abandoned in favour of a more market-led process. Through the criteria applied to discretionary and generic grants governments can influence activities formerly regarded as outside the research process. The scope of activity labelled as 'science policy' has widened.

4. Rural Industry

Several factors mitigated against evaluation of the efficiency and effectiveness of the knowledge produced for use in rural production. These include the informal, fragmented nature of agreements between the users and producers of knowledge in the rural science policy community; the traditional distaste of scientists for accountability; and the unwillingness of governments to intervene in what was seen as an essentially market relationship even though the majority of rural research funds came from the public purse. It was not until the mid-1970s that government began to question the amount of public money expended on rural research.[63] The establishment of the Australian Bureau of Agriculture and Resource Economics and the Bureau of Rural Resources, together with the increased accountability expected of the Department of Primary Industry by the Fraser government, and the techno-economistic values which the Hawke government applied to rural research, have led to greater selectivity in deciding the research to be undertaken; and also to the adoption of much wider parameters for the cost/benefit analysis to which potential research projects are now subjected.

4.1 Evaluation in 1965

The informal nature of agreements between rural producers, and scientists in the various research organisations, follows, until the 1980s, the traditional pattern of scientists' expectations of autonomy in the decision-making processes of subgovernment. The lack of contractual obligations between producers' associations and researchers allowed the dominant participant in the relationship to control the direction of research. This seems to have varied between industries and through time. It is noted in chapter 4 that wool growers proscribed research on artificial fibre/wool blended textiles because of their insecurity about the growing use of synthetic fibres. Their vision of the market was limited to pure wool textiles. Other analysts report that

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63 The Industries Assistance Commission calculated that in 1975 \$200m was spent on rural research. This sum is almost twice the entire budget appropriations for CSIRO in that year. Marsden et. al., *Returns on Australian Agricultural Research*, p. 3.

scientists dominated the selection process with little thought about the economic or financial implications of the application of the research results.[64]

The two-way production-research model which had been so successful in Australian rural research was described by Moule of the Australian Wool Board in 1969. He noted that agricultural research in Australia should be seen very much as *industrial* research in that results have to be produced in such a way that they can be incorporated into farming practice. Similarly, researchers needed to be aware that farmers are themselves a source of innovative ideas. The process can be seen as a set of sequential yet interdependent stages:

1. operations research techniques are used to decide whether a given problem is not simply a matter of misapplied technology;
2. researchers investigate the problem to see whether it can be resolved using existing knowledge;
3. if no solution exists researchers work on producing basic research which will lead to that particular solution, i.e., directed basic research;
4. the basic knowledge is then tested and, through operations research techniques, becomes applied research which can be used in farm management;
5. economic assesments are then made to ensure that the use of the new techniques will result in increased production.

The same process is applicable in the case of new processes arising directly from the laboratory or the farm which are not problem-based but which may increase productivity.[65] Moule says that this selective approach was developed in wool research because the large capital reserves built up in the profitable 1950s began to be depleted in the 1960s. This meant that: '...discriminating choices had to be made against established priorities for the industry's need for science and technology'. The supply of funds to the envelope of resources had slowed to a steady state pattern. The problem for Australian farmers was that:

> Institutionalized research for primary producers is conducted in an atmosphere of stable, 'big business' and without the pressing compulsion to survive; its results are meant to be used by 'small business' conducted in unstable environments.[66]

Moule was concerned that scientific autonomy in large organisations such as CSIRO and the universities allowed scientists to become isolated from the realities of the markets in which the users of their research operated. If this scientific autonomy was

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64 David Morrison, 'Evaluating Research Benefits: The Western Australian Experience', *Agricultural Science,* New Series vol. 4, no. 2, pp. 17-20, p. 17.

65 G.R. Moule, 'Research and the Woolgrower', *Australian Journal of Science,* vol. 32, no. 5, 1969, pp. 176-183, p. 178.

66 Ibid., p. 182.

compounded by lack of administrative accountability and foresight in selecting the direction in which research should proceed, then rural research would remain narrowly focused and oriented to the solution of scientific problems rather than the expansion of markets.

However, the use of such processes was not widespread. It was not until rural economists began to analyse the costs and benefits of rural research that governments began to appreciate or express concern about the lack of rigour that scientists had applied to decision-making about the rural research they undertook. In 1975 the IAC criticised the almost complete absence of evidence about the costs and benefits of allocating funds to particular problems and areas of research, given the huge government investment in rural research.[67] A subsequent cost-benefit study of the CSIRO Division of Entomology revealed that, in the large rural industries of sheep, wheat and beef, every major scientific success, which required approximately six person years of research effort, would double the benefits accruing to the Australian community.[68] The implication was that such economic insights should be built into the processes of selecting and evaluating projects for rural research.

As part of the economic rationalisation of public spending on rural research in 1981 Edwards and Fairbairn were commissioned by the short-lived Commonwealth Council for Rural Research and Extension to develop and apply to rural production in Australia a model for measuring the benefits accruing to the community. They estimated that research which resulted in a 10 per cent reduction in production costs would bring gains to Australia of between 70 and 90 per cent of total world gains if the rest of the world's producers did not have access to the technology. If the research results were available to overseas producers Australia's share of the gains would drop to 10 per cent.[69] These and other enquiries showed that, in order to be effective, rural research needed to be aligned as much with future markets as with current problems for the country to obtain the optimum benefit from public spending on rural research.

4.2 1990: co-ordination, corporatisation, and concentration

The Hawke government's policy of changing the priorities of the science policy community in Australia meant that, from 1983, some rural researchers were expected to manage with a restricted envelope of funding. The emphasis on producing value-added exports in priority areas meant that researchers outside those areas were faced with the prospect of justifying their share of the budget.[70] The replacement of conservative ideologies by techno-economistic expectations in rural science policy

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67 Industries Assistance Commission, *Financing Rural Research,* p. 2.

68 Marsden et. al., *Returns on Australian Agricultural Research,* p. 15.

69 Edwards &. Freebairn, *Measuring a country's gains from research,* p. 12.

70 As Jones said in reply to a CSIRO entolmologist complaining about cuts to his research program: 'Well, I must say that I'm sceptical that we're going to have a cotton-led recovery in Australia.'
Jones, 'The 1984 Science and Technology Budget', p. 247.

meant the introduction of evaluation processes at all levels of decision-making in the rural science policy community.

The government's strategy for rural research involved, among other changes, the establishment of a Primary Industries and Energy Research Council to co-ordinate policy; the setting up of the Bureau of Rural Resources to analyse and evaluate government expenditure on rural research; and the restructuring of the Rural Research Trust funds into Councils and Corporations. All these initiatives included a strong commitment to the processes of selection and evaluation. The Minister for Primary Industries and Energy, in 1990, identified process evaluation as described by the OECD to be the method of choice for primary industry in Australia.[71] Process evaluation is concerned with assessing managerial effectiveness and efficiency in achieving objectives. Performance indicators such as the pattern of budget allocations, the speed of processing proposals and the effectiveness of linkages between agencies are assessed by such means as interviews, questionnaires and workshops involving representatives of producers and customers/clients.[72]

At the macro-level, the Australian Bureau of Agricultural and Resource Economics has conducted ex-post analyses of rural research projects which indicate that 10 projects costing the Commonwealth government a total of $160 million had yielded benefits of $2.5 billion to the Australia community, giving a benefit/cost ratio of 16:1.[73] The Bureau is also helping research managers to develop ex-ante evaluation frameworks which can be used to formalise many of the implicit, intuitive judgements which need to be made in 'picking winners' when allocating user funds. The variables which need to be built into the selection criteria are:

- the level and cost of resources to be committed to research, development and evaluation of the new technology;
- the cost saving associated with the new technology in each industry;
- the international transferability of the technology;
- the probability of success;
- the expected life of the technology;
- the adoption rate and ceiling level of adoption;
- the key economic parameters of the industries (elasticities, prices and quantities); and
- the existence of key external benefits or costs to be accounted for.[74]

The range of variables indicates the international, market-oriented context in which projects are evaluated. Ease of international transferability reduces the gains to Australian producers and should therefore be low. Technology with a long life expectation increases the cost-saving advantage for Australian producers. The

71 Kerin, Opening Addresses for *SCA Workshop on Research Priorities,* p. 4.

72 OECD, *Evaluation of Research: a selection of current practices,* OECD, Paris, 1987, pp. 38-40.

73 CSIRO pledges to help farmers', *Australian,* February 6 1992, p. 4.

74 Brian Johnston, 'Economic criteria and procedures for allocating resources to research', in Bureau of Rural Resources, *SCA Workshop on Research Priorities and Resource Allocation for Rural R&D*, pp. 26-34, p. 32.

adoption rate quantifies the likelihood of the new knowledge being used by Australian producers. The incorporation of similar processes of evaluation into the variable of the costs of research and development indicates the importance that key decision-makers in the rural science policy sub-government attach to the process of evaluation.

At the meso-level the Bureau of Rural Resources has been given the role of undertaking process evaluation within the rural science policy community. For example, in 1988 and 1990 the Bureau organised workshops which examined the organisation, funding, priorities and resource allocation of rural research and development. Representatives of all sections of the rural science policy community listened to a range of speakers from the Department of Finance, CSIRO, State Departments of Agriculture, Rural Research and Development Corporations, the universities and the ARC. They were then asked to consider how the system of producing new knowledge for rural production in Australia could be improved and to vote on a series of questions about what needed to be changed and how this could be achieved.[75]

All participants agreed on the success of the corporatisation of the Rural Research Trust Funds in formulating research strategies at the micro-level of rural industry interaction with the science system.[76] Corporatisation has involved the formalisation of the relationship between rural producers and researchers on a strictly commercial basis. One rural research trust fund which made an early transition to corporate status is the Australian Meat and Livestock Research and Development Corporation (AMLRDC). The Executive Director tells of the transition from a passive system of selection between submitted projects from scientists 'with a cause to support', to an active, ex-ante selection system of three phases:

- examination of the factors affecting profitability for a five-year period, including consumer, demographic, climatic, economic, political and technological trends both in Australia and overseas;

- backward planning of each step with regard to the allocation of resources using the World Bank system of feasibility studies which examines the industry background, the core of the problem, the goal and steps to achieve it, the best contractors to do the research work, the total cost and an estimate of eventual benefits;

- tightly binding contracts with scientists to complete the projects on a fixed price basis over 2 and 3-year terms.[77]

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75 Bureau of Rural Resources, *Workshop on the Organisation and Funding of Rural Research,*; and Bureau of Rural Resources, *SCA Workshop on Research Priorities and Resource Allocation for Rural R&D.*

76 Bureau of Rural Resources, *SCA Workshop on Research Priorities and Resource Allocation for Rural R&D*, p. 98.

77 Ian McCausland, 'AMLRDC research priorities and resource allocation', in *SCA Workshop on Research Priorities and Resource Allocation for Rural R&D,* pp. 91-101, pp. 92-93.

The AMLRDC has also conducted ex-post evaluations on six research projects funded wholly or in part by the Corporation in order to identify successful factors affecting levels and rates of return. It was found that all six programs had been successful with the lowest benefit/cost ratio being 6:1 and the highest 74:1.[78]

However, it is not only the corporations which can benefit by such evaluations. Staff at the Western Australia Department of Agriculture have found that when researchers have participated in the process of applying ex-ante and ex-post evaluation models to existing or proposed research projects, they were able to improve the planning and execution of their research.[79]

Corporatisation and concentration of decision-making about the allocation of resources to rural research has occurred even at the level of potential rural industries. The Rural Industries Research and Development Corporation (RIRDC) was established in 1990 to foster innovation in those areas of agricultural production less likely to attract private sector funding and to manage the industry levies of the 14 smaller Rural Research Councils. Each Council must comply with general accountability requirements which include:

- the submission to the Minister of a strategic five year plan for research and development in the industry;
- the submission to the Minister of annual research and development programs;
- the evaluation of proposed projects by criteria which fit research priorities;
- the publication of an annual report which evaluates performance against strategic objectives;
- the presentation of the annual report by the Chairperson of each Council to a meeting representative of the industry served;
- the requirement that each of the above elements should be prepared by extensive consultation with the industry.[80]

The reward to the industry of such increased accountability is the autonomy and flexibility resulting from the fact that the Councils will not be required to submit individual research proposals or minor alterations to budgets for ministerial approval.

In addition to established Councils for such industries as chicken meat and honeybees the Corporation allocates funds to such developing industries as essential oils, goat fibres and wildflowers. The RIRDC has adopted a two-stage assessment procedure for the allocation of funds to research projects. A two-page preliminary application is assessed by the Corporation. Applicants who pass this stage are then expected to submit detailed project descriptions in line with the Corporations guidelines which require specific details of how the new knowledge is of relevance to the industry, and of the expected financial gains from the application of consequent

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78 Greg Martin, 'Returns from research: meat and livestock, *Agricultural Science,* New Series, vol. 4, no. 2, March-April, 1991, pp. 21-24, p. 22.

79 Morrison, 'Evaluating Research Benefits, p. 19.

80 The legislation is ambiguous about whether or not individual Councils should report to the Minister or to the Rural Industries Research and Development Council.
Rural Industries Research and Development Corporation, *Annual Report 1990-91,* pp. 3-4.

new techniques. Researchers whose projects are selected are then required to sign agreements which promise funding for the entire stipulated length of a project in return for negotiated rights with regard to the management of intellectual property and of resultant income. The agreements include provisions for the termination of the agreement if satisfactory progress is not maintained.[81]

4.3.Summary: rural research evaluation

It is clear that the processes of evaluating research in the rural science policy community has undergone considerable change since 1965. The dominant influence of either scientists or producers has had to accommodate the increasing demands of government for accountability for public research funds; and that research so funded should be directed to improving Australia's competitiveness in the global economic community. The traditional image of rural research as being the most efficient and relevant of all sectors of research began to fade as economic cost/benefit analysis revealed that only 9 per cent of such research was user-funded, and that forward planning could double the gains to Australia from the application of rural research results.

It was not until the election of a government with less interest in maintaining the staus quo of rural producers than with pursuing techno-economic objectives involving the direction of public research funds to the development of value-added production, that radical changes were made to the processes of evaluation in rural research decision-making. The result has been that selection criteria are now based not only on the solution of rural research problems, but on the potential of proposed projects to enlarge and diversify export markets and value-added components in rural research. By introducing these criteria, governments have forced producers and researchers to place their activity in the wider context of Australia's global economic performance. This has always been the case for the traditional export industries of beef, wheat and wool but is now a requirement also for smaller developing industries which may not previously have considered international markets but which must now do so in order to recieve development funds.

Researchers must now justify their expenditure to councils and corporations that are directly accountable not only to governments and producers, but also increasingly to private investors, for the money they allocate. Legally constituted, contractual agreements place time and relevance constraints on the research undertaken. Researchers may see this development as stifling their professional creativity but the tighter processes of research evaluation ensure that rural research funds return benefits to the whole community and do not simply underwrite individual researchers' international reputations.

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81 Ibid., pp. 10-11.

CONCLUSION

Between 1965 and 1990 there were major changes in the way in which publicly funded research projects were prioritised, selected and evaluated according to techno-economistic criteria. There is some evidence that similar processes were employed in such areas as wool research in the 1960s but it was not until the late 1980s that systematic prioritisation and evaluation were introduced into all the sectors of the science system under examination here. The processes were introduced with least resistance into the manufacturing and rural sectors in which research is inherently market orientated. In the manufacturing sector the transition was from patterns of selection by individual firms of projects at the product level, to industry-level prioritisation by subgovernmental agencies composed of political, scientific and commercial actors. A major initiative was the introduction of a non-prioritised tax concession for private research and development. While this seems counter to the argument of a government policy of increasing prioritisation, its introduction is in line with the wider ideology of techno-economism in which governments intervene to foster greater market orientation in research, and more awareness in industry of research as a form of long-term investment.

In the rural sector the traditional selection processes of collective industrial research were re-organised into corporations rather than the traditional trust funds. The development of sophisticated mechanisms of research evaluation by rural economists has systematised the process of selection formerly the prerogative of scientists in varying relationships of dominance and dependency with producers.

In the higher education sector the processes of prioritisation, selection and evluation were resisted by scientists who invoked the ethos of science to defend their autonomy against the introduction of financial accountability mechanisms generally considered normal in other areas of public activity. The same resistance was expressed in CSIRO despite the statutory expectations of the Organisation to serve the needs of industry. It was the imposition of new rules (written into the 1986 Act), new resource requirements (in the form of externally generated funds) and ideas (including the appointment of a Chief Executive with extensive commercial experience) by the superstructural subgovernment which generated new relationships within CSIRO science policy community. Similar inducements to change were imposed on the higher education science subsystem.

The knowledge produced by the science system is the single most significant output of science policy. The change from nationalistic-cultural to techno-economistic objectives for the science system necessarily entails changes in the type of knowledge produced and in the ways in which the knowledge is used. The final chapter in this section looks at the way in which changes in resource allocation, structure and evaluation processes have affected the type of knowledge produced by the science system in Australia and the changing uses to which this knowledge is put.

CHAPTER 8

KNOWLEDGE AND ITS APPLICATION

1. THE CONCEPT OF KNOWLEDGE IN SCIENCE POLICY

Scientific knowledge is a central issue in science policy. If the process of creating knowledge by the scientific method is viewed as a cultural and social achievement then the knowledge produced is intrinsically valued. Governments or private foundations provide the economic and ethical resources for its production, and decisions about the type of knowledge to be produced are largely internal to the science system. Such knowledge (defence science apart) is not only a national but also an international public good and can be used to achieve such social objectives as better health and a cleaner environment. The publication of results in prestigous refereed journals is the acknowledged form of competence in the international scientific community for this type of research. The number of such papers published by a nation's authors becomes a measure of national cultural achievement. Since 1972 science policy analysts in the international attentive public have used such measures as an indicator of the output of scientific activity.[1]

If on the other hand, the creation of scientific knowledge is seen as an aspect of economic activity then the knowledge produced is intermediate to increased economic production. In an ideal market situation, decisions about the type of knowledge to be produced would be negotiated between the users and producers of the knowledge. The results of this research are usually regarded as the intellectual property of the user/producer and are protected by an international system of patents, licences and royalties. Patent activity is seen as a useful indicator of national innovative activity, though it must be recognised that not all patents are based on scientific knowledge and that not all innovations are patented. In situations of market failure governments intervene to fund the production of scientific knowledge perceived by their officials or advisers as being of national economic importance. In this situation the opportunity exists for private producers to influence governments' perceptions of the need to subsidise research and development in the private sector.

This thesis shows that, in Australia, both State and Commonwealth governments have traditionally intervened in the production of scientific knowledge for nationalistic, social and techno-economic objectives by providing, wholly or in part, the necessary resources. Despite this government involvement, scientists have usually made the decisions about the type of knowledge to be produced. This has resulted in an emphasis on basic science because the ability to produce this type of knowledge is most highly valued in the scientific community. As governments

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1 Department of Industry, Technology and Commerce (DITAC), *Measures of Science and Innovation,* Science and Technology Policy Branch, Canberra, 1987, pp. 184-202.

impose increased accountability on scientists there should be a demonstrable increase in the production of applied science, as measured by patents and collaborative agreements; and a decrease in the production of basic science, as measured by the publication of scientific papers. An examination of the type of knowledge produced in different sectors of science in Australia should reveal the extent to which scientific knowledge has become part of national economic achievement rather than part of national cultural achievement.

2. Indicators of National Scientific Output

There are two internationally recognised indicators of scientific output: bibliometric analysis and patents. In recent years Australian government agencies have also used the 'know-how' payment to measure innovative activity. This indicator will also be used here and is discussed later in the chapter. The following section explains the terminology and use of bibliometrics and patents.

2.1 Bibliometrics

In 1967 Pritchard coined the term 'bibliometrics', defining it as: 'The application of mathematics and statistical methods to books and other media of communication'.[2] Bibliometrics has been used since 1972 as an international indicator of scientific activity and involves counting the number of published research papers in a given range of journals, and the number of citations to those papers. There are limitations to the range of scientific knowledge measured in this way. Bibliometric indexes are biased: firstly towards English language journals; secondly, towards journals published in the USA; thirdly towards clinical medicine; fourthly, to traditional areas of research rather than new ones; and fifthly, towards established rather than new journals.[3] Nevertheless, bibliometrics can be seen as a measure of the quality of national scientific output in basic research.[4]

In Australia such indicators have been in general use only since 1987. Neither the 1973 Project Score survey, nor the original 1978 ASTEC Report, used bibliometric indicators. Since 1987 DITAC has used the Science Literature Indicators Data Bank compiled by Computer Horizons Inc. (CHI) for the National Science Foundation from the Science Citation Index (SCI).[5] A familiar catchcry of Australian scientists has become the statistic that, with only 0.2 per cent of the world's population, Australia produces 2 per cent of the world's publications as measured by CHI. This figure has remained stable throughout the period from 1973 to 1986. By far the largest proportion of papers is published by scientists in the USA with 36 per

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2 Ibid., p. 202.

3 Ibid., p. 185;
ASTEC, *Profile of Australian Science,* AGPS, 1989, p. 189.

4 Ibid., p. 313.

5 This index monitors 3100 of the 25,000 scientific journals published world-wide on the basis that 84 per cent of all the internally significant scientific knowledge is published in 2000 journals.

cent of the total. Traditionally, scientists from the UK have ranked second with 8-9 per cent, but in recent years Japan has been challenging that position.[6] In terms of scientific articles per 100,000 population Australia ranks fifth behind Sweden, Canada, the United States and the United Kingdom. In terms of overall output Australia ranked ninth in 1986.[7]

ASTEC has evaluated Australia's research outputs on the basis of the citation and bibliometric analyses.[8] The areas of strength are those in which Australia's share of citations and papers are higher than the two per cent average and the weaknesses in areas below that level.[9] The problem for governments is that these measures are of significance to scientists for whom international status is of paramount importance, but are of little use in evaluating the effectiveness of scientific production at the national level. As the authors of the ASTEC Report ask:

> Is it better to concentrate Australian research in large areas which are dominated by other countries, but which have substantial Australian publication activity relative to our total activity or is it better to concentrate on smaller areas of scientific interest in which we are the leading country? We have to ask if these areas give a sufficiently comprehensive coverage of priority areas of science which are necessary for Australia's future development.[10]

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6 As yet unpublished studies show that Japanese companies published an average of 21 per cent more scientific papers in 1989 than they did in 1984. Some companies increased their output by 90 per cent. Hicks says that there are three main reasons for the increase. Firstly, Japanese companies in some industries such as veterinary science and pharmaceuticals are under a statutory requirement to publish some of their results. Secondly, more basic science is being undertaken by Japanese companies; and thirdly, the publishing rate has previously been low because the practice of life-time employment has diminished the career value of international publication.
Dr Diane Hicks, 'Japanese Corporate Science', Seminar, Science Policy Research Unit, Sussex University, 6 December 1991 (unpublished).

7 DITAC, *Australian Science and Innovation Impact Brief*, p. 30.

8 In 1990 ASTEC and the Centre for Technical and Social Change at Wollongong University jointly held a Forum to discuss the ASTEC Profile of Australian Science Report published in 1989. The 463-page Report is a compilation of data on basic science in Australia in terms of human and financial resources expended and in terms of scientific output. Approximately sixty per cent of the Report is devoted to bibliometric and citation analyses of scientific disciplines in Australia.
ASTEC, *Profile of Australian Science*, AGPS, 1989.

9 They are:

strengths	weaknesses
cardiovascular research	preventative medicine
neuroscience	community medicine
immunology	mental health
fertility	pharmacology
veterinary medicine	microbiology
animal and plant physiology	whole body biochemistry
genetics	economic geology
nutrition	soil research
virology	water resources research
astronomy	mariculture
atmospheric research	solid state physics
geology	nuclear physics
civil engineering	parts of mathematics
fluid dynamics	
mechanical engineering	

Ibid., p.xi.

10 Ibid., p. 210.

This raises the fundamental issue of why it should be necessary for Australian scientists to compete in the international science status system. Apart from those scientists in the higher education science system who are pursuing international careers in basic science, the question arises of whether other scientists, particularly young scientists who are not of world class standard, should be encouraged by their senior colleagues to devote their productive creativity to achievement at this level. The ASTEC authors themselves cite an OECD study which concludes that only five or ten per cent of scientists create 75-90 per cent of the significant advances in science.[11] The traditional rationale is somewhat of a *credo* for the science system and is stated again in the introduction to *Profile of Australian Science:*

> Since basic or long term research has been shown to have a measurable effect on total factor productivity in private firms, a link can be drawn between basic research and private R&D....Basic research conducted in Australia can also improve the competitiveness of Australian firms.[12]

ASTEC finds that the problem lies with the failure of Australian manufacturing industry to exploit commercially the scientific knowledge created by the basic science system which is of international standing. According to ASTEC it is not the fault of scientists if they choose the status system of international science in preference to the applied science system in Australia:

> It is therefore understandable why so many basic researchers are decoupled from the industrial system, and prefer to relate to the international science community in preference to assisting the economic development of Australia.[13]

However, we can, by examining the publication record of other countries, examine the extent to which citation and bibliometric analyses are indicators of national economic well being. The data given in *Profile of Australian Science* show that such economically successful countries as Japan and Germany publish only three times the scientific papers published by Australian scientists, while scientists in the UK publish four times the number. Economically successful Switzerland and the Netherlands publish fewer papers than Australia, even in the areas of engineering and chemistry in which those countries have giant transnational companies.[14]

ASTEC's solution to the problem is to maintain the level of funding for basic science and to increase funding for applied science. Funds for basic science, argues the Council, should be allocated on a competitive basis in order to identify those few excellent scientists by whom the advances are generated. The general level of 'sophisticated' scientific skills in basic science needs to be maintained so that Australian scientists can gain access to knowledge created overseas. Since this

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11 Ibid., p. 312.
12 Ibid., p. vii.
13 Ibid., p. xiii.
14 Ibid., p. 195.

knowledge is created increasingly in consortia of large companies, Australian scientists will have to be in a position to trade skills for knowledge. Some basic research will also need to be done: 'to fulfill our custodial duties for this part of the world' (i.e., for nationalistic-cultural objectives). ASTEC advocates that the best place for both these types of basic research is in the universities where scientific labour is inexpensive and undirected.[15]

Few voices in the international science policy community, and almost none in Australia, are raised against these arguments.[16] One who does question the relationship between bibliometrics and economic activity is Kealey in the UK. He argues that university science is the child of economic growth rather than its parent: that it is a consumer good rather than a producer good. In particular he criticises the use by Martin and Irvine of the Science Policy Research Unit of bibliometric indicators in comparisons of national public funding for research and development To support his argument he uses statistics which show an inverse relationship between the rate of scientific publications and economic growth. He points out that this relationship has not changed since Williams (see chapter 3, section 2.1.b) challenged its validity 40 years ago.[17]

2.2 Patents

A patent is defined as:

> A government grant to an inventor, his heirs or assigns, for a stated period of time, conferring upon him a monopoly of the exclusive right to make, use or vend an invention or discovery.[18]

The granting of patents in Australia became the responsibility of the Commonwealth Government in 1904. Since then the Patents Act has been amended only twice, in 1952 and 1968, to expedite increases in applications.[19] In 1980 Australia became a signatory to the Patents Co-operation Treaty under which patent applications can be filed simultaneously in several countries. In 1990 the Act was completely redrafted to reflect changes in the type of knowledge being created and to allow freer access to the knowledge contained in patents. The redefinition of what constitutes an 'inventive step' has made the granting of patents less likely and has brought the Australian system into closer alignment with the European system. The new Act holds that prior

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15 Ibid., pp. xii-xiii.

16 Bourke and Butler have been following the UK debate and recently urged caution in using bibliometrics as an indicator of overall decline in scientific activity in Australia.
Paul Bourke & Linda Butler, 'Australian Science: "Some Worries, Mate"', *Campus Review,* 18-24 November, 1993, p. 9.

17 'Government funded academic science is a consumer good not a producer good: a comparative reassessment of Britain's scientific and technological achievements since 1794 and a comment on the bibliometry of B. Martin and J. Irvine', *Scientometrics,* vol. 2, no. 2, 1991, pp. 369-394, pp. 384-385.

18 *The Macquarie Dictionary*, Macquarie Library Pty. Ltd., Sydney, 1981, q.v.'patent'.

19 Lamberton, *Science, Technology and the Australian Economy* p. 6.

knowledge of an invention published outside the patent system can invalidate a patent claim. Patent applications in Australia must now also be tested for inventive step against internationally available knowledge.[20] Researchers must therefore consider patent activity before research results are disclosed to a 'third person'. This must include applying for international patents rights as well as patent rights in Australia.[21] Patent recognition must now be sought in advance of recognition within the national and international scientific communities.

Patent-awarding systems differ from country to country in the way in which patents are applied for; the novelty requirements of what is considered to be new knowledge, products or processes; the extent to which confidentiality must be observed before patenting; and the length of time for which a patent can be held.[22] The actual granting (or 'sealing') of a patent is usually an indication that commercial production of an innovation is about to take place. Foreign companies lodge patents in Australia in order to protect products and processes developed overseas. The use of this new technical and scientific knowledge requires payments of licence fees and royalties and these payments can also be used as an indicator of technological dependence. These measures can be combined to give a picture of the changing pattern of inventive activity in Australia between 1965 and 1990.

3. Higher Education

The output of the higher education science system consists of trained scientists and of knowledge. The trained scientists enter other sectors of production, stay in academe or pursue careers overseas. In addition, there have always been scientists who have moved between the worlds of academe and private production, thereby increasing the transfer of knowledge and skills.[23] The majority of the knowledge produced has, however, traditionally been regarded as a public good and published in scientific journals of varying status in the international scientific system. Even knowledge produced by arrangement with industry associations has generally been disseminated

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20 The Industrial Property Advisory Committee noted in 1984 that the existing patent system had social costs in terms of the monopolisation of innovative knowledge. The Act excludes biological processes for the generation of human beings but McKenna considers that the Act did not go far enough in terms of the definition of 'an invention' which retains much of the language of manufacturing used in the original Statute of Monopolies of 1623.
Marshall McKenna, 'Patent Act 1990: Revision or Restatement?', *Western Australian Law Review,* vol. 21, no. 2, 1991, pp. 383-390.

21 Errol Harwood, 'Protect, then Publish or Perish', *Australian Physicist,* vol. 27, no. 11, November 1990, pp. 241-242.p. 242.

22 Ibid..
McKenna, 'Patent Act 1990: Revision or Restatement?', pp. 383 & 386.

23 For example, of the scientists interviewed for this thesis, Professor Arthur Birch worked for many overseas pharmaceutical companies including ICI and Hoffman LaRoche; Professor Richard Collins worked for AWA before taking a Chair in Applied Physics at Sydney University; and Professor Howard Worner was at Melbourne University before working for CRA, BHP and others, then returning, at the age of 70 to a position at Wollongong University.
Professor Arthur Birch, Interview, 29.4.90.
Professor Richard Collins, 8.11.89.
Professor Howard Worner, 3.11.89.

through public sector extension services. Although still predominant, this pattern of knowledge production and application is changing as more higher education institutions market, through specially created companies, the knowledge produced by their scientists.

The quantification of university research output is not well developed in Australia. Analysis of SCI data and publications is sporadic and there is always a lag of up to five years between publication of scientific papers and publication of the data about scientific papers.[24] This means that publication and citation data is of little use as indicators of short-term trend, and therefore not actively pursued by decision-makers in the science policy community. It is probably for this reason that DITAC has omitted such data from its latest series of science and technology indicators and concentrates on higher education research funding as the measure of 'performance'.[25] More meaningful indicators of government objectives for higher education research are the establishment of university research companies, and of Co-operative Research Centres in which funding is contingent upon commercialisation.

3.1. Bibliometric analysis of basic research

The previous lack of interest in bibliometric studies is indicative of the absence of expectations of accountability by the science policy community of the higher education sector. Quantification of research output in the form of the allocation of human and financial resources has traditionally (since Project Score in 1968) been considered an adequate measure of performance. The most comprehensive set of Australian data was published by ASTEC in 1989 using statistics supplied by the Science Policy Research Unit of the University of Sussex. The earliest data in the set are from 1975.

The data indicate that Australia's share of world scientific publications barely altered between 1975 and 1986 while the number of researchers in higher education more than doubled during the period. Despite the time lag between research, publication and analysis of publication, it appears that the downturn in scientists and engineers in the early 1970s did not affect the share of publications. The downturn in 1986 may be due to increasing publications from Japan and the rest of the world.[26] The lack of statistics for later years highlights the inadequacy of bibliometrics as a quantitative indicator in assessing the immediate ouputs of research and development. It is impossible to ascertain whether the downturn in 1984 has been maintained until publication and citation measurements catch up with actual publication of papers.

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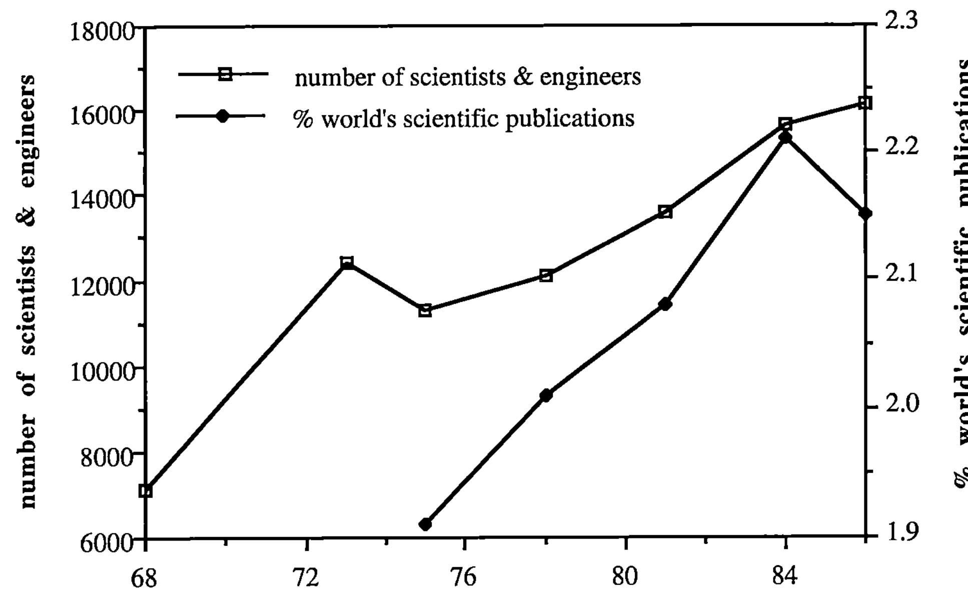
24 Steve Sunter, CSIRO Australia Index, Personal Communication, 30.11.92

25 DITAC, *Australian Science and Innovation Resources Brief 1992.*

26 ASTEC and DITAC report different figures for 1984. The DITAC figures for 1984 (2.21) and 1986 are used here. The ASTEC figure for 1984 was 1.99.

Figure 8.1: The relationship between researchers in higher education and Australia's share of world scientific publications



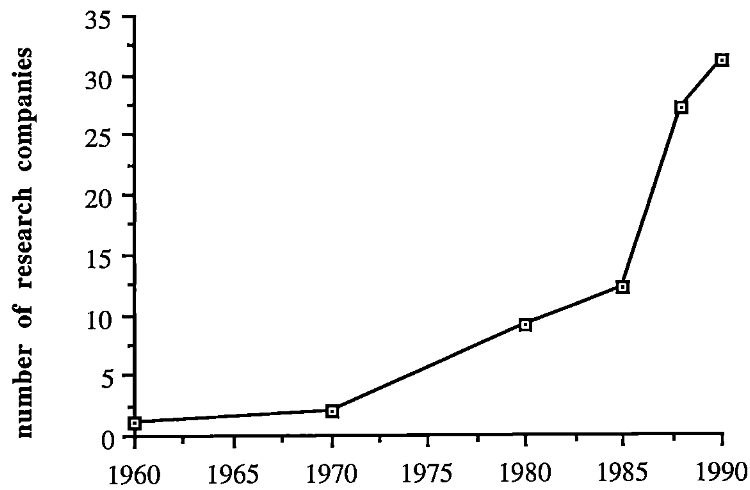
Data source: ASTEC, *Profile of Australian Science,* p. 188;
DITAC, Australian Science and Innovation Resources Brief 1992, p. 52

3.2. The marketing of higher education research

A more immediate response to science policy is the increasing extent to which universities are marketing research results. The commercialisation of university research results began formally in 1959 when the University of New South Wales established Unisearch to provide an interface between the University and public and private industry. This form of interaction in the application of new knowledge increased slowly. By 1970 there were still only two such companies; by 1980 there were 9 and by 1990 there were at least 49 of which 31 offered private research and development or intellectual property services.[27] The total number increased by 138 per cent between 1985 and 1990. Figure 8.2 illustrates the growth of those higher education companies whose activity and/or revenue derive wholly or in part from the commercial exploitation of intellectual property or research and development activity.

[27] Attica, *Directory 1991,* Australian Tertiary Institutions Commercial Companies Association, unpublished report, [confidential access only].

Figure 8.2: The number of higher education research companies 1960-1990



Data source: Attica, *Directory 1991*.[28]

The sudden increase at a time when the Government has been urging higher education research establishments to co-operate more with industry and commerce must be seen as a direct response to this aspect of science policy. Universities establish these companies for various reasons but the mission statement of Unisearch is probably typical of many:

> The objectives of Unisearch are to:
> - serve the wider community with the provision of an extensive range of scientific, technological and professionals skills and resources of the University, and to
> - serve the University by increasing the utilisation of its skill and resource base.
>
> In pursuing these objectives Unisearch promotes the University as an institution of relevance to the community; and, at the same time, provides University staff with a channel of contact into the activities and workings of the community enabling their teaching and research expertise to be attuned to issues of current importance.[29]

Steele and Lindley found that, among a sample of six university companies which had been in existence for more than five years, the establishment of such companies had the potential to create conflict among academic staff by introducing rewards for non-academic behaviour into the university system. The conflict is especially pronounced where professorial appointments are made, on the basis of entrepreneurial skills, to people with a mediocre record of scholastic achievment.[30] This conflict is a classic instance of the clash between scientific and political ideology.

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[28] Attica. *Directory 1991,* Australian Tertiary Institutions Commercial Companies Association, Attica, unpublished report, [confidential access only].

[29] Unisearch, *Annual Report, 1990-1991,* Unisearch Limited, NSW, 1991, p. 4.

[30] Steele & Lindley, 'Commercializing the Universities', p. 182.

The norms of communality conflict with the techno-economistic expectations of subgovernment.

3.3. Commercialisation as a contingency in 1990

There are three programs within the higher education sector of science policy which most clearly demonstrate the Hawke Government's intention to achieve the utilisation of the results of research: the Co-operative Research Centres; the Industry section of the Australian Postgraduate Research Awards; and the Senior Research Fellowships in Industry. They are all funded on the premise of inducing application in private economic production of the new knowledge, skills and training procedures generated within the higher education system.[31]

The CRC Program in particular is centred around the active involvement of users of research in the operation of the Centres. Government funding of the Centres is contingent upon the participating organisation providing 50 per cent of the establishment and operational costs for each year of operation. Before funding is granted formal agreements must be signed between each participant and the Commonwealth Government, and between all participating organisations. These agreements include detailed statements about how the results are to be utilised and how issues of intellectual property, licensing and commercialistion of research results are to be managed. The Government has allowed a broad definition of 'research user'. The participant organisation may be a private firm, a rural industry research and development corporation or a public sector organisation.[32] In fact, of the 52 CRCs funded by 1993, only ten did not involve a participant from the private sector.[33]

Summary: higher education

Since 1987 the Commonwealth Government has, by direct and indirect control over research resources, intervened to change the pattern of interaction between researchers in the higher education sector and potential users of the knowledge they produce. The transition for scientists from the production of new knowledge as an international public good, to active participation in its commercial dissemination and utilisation has been a significant shift in the pattern of knowledge production and dissemination in the Australian science system and has thereby caused conflict as commercial and bureaucratic values of accountability and profitability have intruded upon academic notions of autonomy and universalism.

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31 The Australian Postgraduate Research Awards (Industry) provides funds for 60 candidates to undergo part of their research within an industrial organisation. Participating firms must sponsor each candidate to $10,000 or equivalent benefits. The Australian Research Fellow (Industry) Program funds 20 researchers working in industry for twelve months.
ARC, *Australian Research Council Awards 1990-91*, pp. 21 & 23.

32 Department of the Prime Minister and Cabinet, *Co-operative Research Centres Program: Round Three Applications Guide,* pp. 5,6, 12 & 17.

33 *Scitech Technology Directory 1993*, compiler, Jane Ford, Canberra, 1993, pp. 152-168.

4. CSIRO

The function of CSIRO has always been to produce scientific research for use in industry and the dissemination of research results has been a statutory obligation for the Organisation. The changed wording of the Acts expresses the changing expectations of governments in this regard. In the original Act of 1920 the wording of the relevant sub-section was :

> (f) the establishment of a Bureau of Information for the collection and dissemination of information relating to scientific and technical matters: and
> (g) the collection and dissemination of information regarding industrial welfare and questions relating to the improvement of industrial conditions.[34]

In 1926 subsection (g) was omitted and the following paragraph was inserted in its place:

> ...and also that of acting as a means of liaison between the Commonwealth and other countries in matters of scientific research.[35]

The norms of the science system were beginning to take over the original intention that CSIR should produce scientific knowledge for industrial application. The norms were intensified in the 1949 Act which simply stated:

> (g) the publication of scientific and technical reports and papers.[36]

Liaison with other countries merited its own section in this Act. In 1986 the primacy of industrial co-operation over other functions was specifically emphasised:

> 7. Section 9 of the Principal Act is amended-
> (a) by inserting after paragraph (b) the following paragraphs:
> (ba) to encourage or facilitate the application or utilisation of the results of any other scientific research;
> (bb) to carry out services, and make available facilities, in relation to science;
> ...(c) by adding at the end the following sub-section
> (2) The Organisation shall-
> (a) treat the functions referred to in paragraphs (1) (a) and (b) as its primary function; and
> (b) treat the other functions referred to in sub-section (1) as its secondary functions.[37]

The government was in this way writing into the new CSIRO legislation new rules emphasising the way in which its reseachers should approach their results. Firstly they should consider the industrial utility of the research undertaken, and only then should they consider whether the results would be published and whether they should connect their work with that done overseas.

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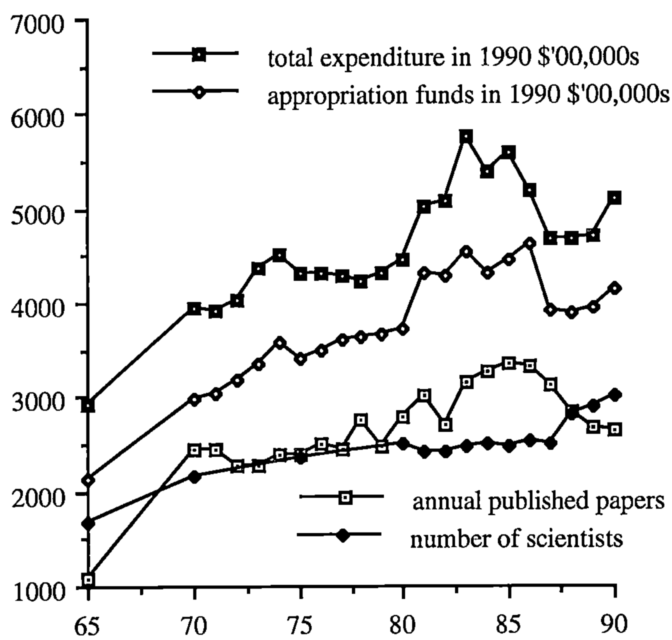
34 Institute of Science and Industry Act ,no 22 of 1920.
35 Science and Industry Research Act ,no. 20 of 1926.
36 Science and Industry Research Act, no. 13 of 1949.
37 Science and Industry Research Legislation Amendment Act no. 121 of 1986.

4.1 Scientific publications 1965-1990

The combination of new rules about the knowledge produced, and new types of funding arrangements, discussed in chapter five, seems to be changing the way in which CSIRO scientists are approaching their work. Figure 8.3 shows the relationship between the number of scientists in CSIRO; the papers they produce; the allocation of funds by appropriation; and the total organisational expenditure for the years 1965 to 1990 (in 1990$m). The relationship between appropriation funding for CSIRO and total expenditure is discussed in chapter five where it is noted that not all of the funding growth comes from the private sector - much of this money comes from other government agencies. The apparent sudden leap in the number of papers published between 1965 and 1969 may be due to different data sources.[38]

Figure 8.3: the relationship between CSIRO funding, the number of scientists and papers published.



Data Sources: CSIRO *Annual Reports* 1965-1990;
CSIRO Australis Index;
CSIRO *Operational Plan 1991-92.*

The figure shows a strong positive relationship between all four variables until 1980. Funds, scientists and publications followed the same pattern of increase and decrease. From 1980 until 1986 the number of scientists remains more or less constant.[39] After

[38] The publications data 1968-90 are obtained from the CSIRO Australis Index but the 1968 figures appear to be incomplete and are not used. The 1965 figure is obtained by counting the number of papers listed in the 1965 Annual Report (at that time all publications were reported each year). Expenditure and appropriations data are obtained from each annual report from 1965 to 1990. The funds are given in units of a hundred thousand dollars in order to allow the four variables to be displayed on a compact graph.

[39] The number of scientists employed by CSIRO is difficult to monitor accurately through time. Only in 1992 did the CSIRO Australia Index begin to assemble the longitudinal data (Sunter,

the restructuring and new legislation of 1986 the real value of funds dropped as did the number of papers published. However, the number of scientists increased. When funds began to rise again in 1989 publications continued to fall. The 1991 figures are included to account for the lag between performance of research and the publication of results.[40] Even allowing for lag it appears that the production of scientific papers by CSIRO staff has fallen even though both the number of scientists and the available funds have increased. In recent years as more research is undertaken in collaboration with private firms, researchers have had to postpone publication for a negotiated time. Consequently the lag between research and publication of results may widen in the future. However, since 1986 there has certainly been an alteration to the traditional pattern of publication.[41]

4.2 The application of research results, 1965

Measurement of the application of the results of research undertaken by CSIRO is more difficult. The traditional indicator of the commercialisation of scientific and technological ideas is the patent but this is not a good indicator of activity in CSIRO.[42] By 1965 CSIRO had developed a policy that patents would only be sought on inventions which seemed 'desirable in the public interest'.[43] The public interest would be served only:

Personal Communication, 30.11.92). Consequently the figures given above are gleaned in various forms from CSIRO Annual Reports. For 1965 and 1970 all the staff were listed in the Annual Reports. The numbers for these years include divisional chiefs, assistant chiefs, senior principal research officers, principal research officers, scientific officers and experimental officers. The figures do not include administrative staff, technical staff or librarians. For 1975 and 1980 exact figures were not given and Annual Reports simply stated a total number of personnel and indicated that approximately one third of these were scientists. From 1979 charts in the Annual Reports included the proportional distribution of professional staff throughout CSIRO but gave no absolute numbers. The 1985-86 Annual Report gave absolute numbers for 1981 to 1986. From 1986 onwards the numbers of professional staff are usually given in graphic form which is difficult to read in numbers less than 100. Often the numbers are contradictory. For example the 1987-88 Report gives a precise number of 2489 professional staff engaged in research but the 1988-89 Report shows in graphic form that there were 3000 professional staff in CSIRO.

[40] Until 1986 the number of papers published closely followed the level of funding. Since then the level of publications has continued to fall even though the level of total expenditure has risen again. Sunter estimated that the exact number of publications cannot be known for seven years. Sunter, Personal Communication, 30.11.92.

[41] This view is supported by Bourke and Butler in their interpretation of Australian bibliometric statistics published in *Science Watch,* the journal of the American Institute of Scientific Information in November 1993.
Bourke & Butler, 'Australian Science: "Some Worries, Mate"', p. 9.

[42] In 1966 Encel and Inglis noted:

> Again, there has been only limited and tardy recognition of the fact that discoveries made in government laboratories are unlikely to be put to practical use unless the government itself establishes machinery for developing and patenting these discoveries.

Encel & A Inglis, 'Patents, Inventions and Economic Progress', p. 573.

[43] J.P. Shelton, 'CSIRO Patents and Research for Industry', *Australian Physicist,* vol. 2, no. 1., January 1965, pp. 3-6, p. 4.

1. When there is a danger that others may obtain patents covering the results of the Organization's research....
2. When it is desirable for the Organization to maintain an interest in the quality and technical efficiency of production....
3. When it is likely that an invention will not be developed and exploited commercially unless covered by patent....
4. Where an invention may assist in maintaining or extending the use of Australian products overseas....
5. Where substantial royalties may be earned, especially from industry overseas.[44]

Shelton reports that the objective of the patent policy was to bring about the widest possible use of research results within Australia by Australian manufacturers and producers. Nominal royalties and licence payments ensured that these were available at the least possible cost to the domestic developer. The policy was different for overseas manufacturers who wished to use CSIRO research results. In these cases the maximum royalties were charged. In 1965 CSIRO took out 32 patents in Australia and overseas, 22 per cent of which were connected with the wool industry. The patents resulted from research done in 15 of the 32 divisions of CSIRO.[45]

White says that when such patents were taken out by CSIRO the Organisation would then 'seek to interest appropriate firms in the discovery' and grant such firms exclusive or non-exclusive licences. According to White careful administration of patents did not result in total secrecy which would deny those results to other developers. However, he also said that the mode of dissemination had to be different in rural industry from that in manufacturing industry because of the collective nature of rural production. Research results in rural industry were disseminated through research notes, newsletters, location reports, open days and State Government agricultural extension services.[46] In manufacturing production CSIRO interacted much more on an individual basis with firms which wanted specific results. Shelton bemoaned the fact that foreign firms were often the first and only developers to express an interest in commercial applications of CSIRO results:

> Until Australian industry undertakes a significant proportion of its own development work it will not be able to make fully effective use of CSIRO research results which were it not for the problems of local development, might have been applied to greater benefit in Australia.[47]

Users of CSIRO research did not always agree with the Organisation's administrators that research results were applicable. In the experience of one private enterprise manager talking to scientists about the commercial application of their work required that researchers:

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44 Ibid., pp. 4-5.
45 CSIRO *Eighteenth Annual Report,* pp. 108-109.
46 White, 'Administration of Scientific Reseach', p. 125.
47 Ibid., p. 6.

> ...dig these fellows out of their scientific cocoon and awaken them to the fact that there are other realities than pounds of paper on a shelf.[48]

Other research managers of significant Australian firms agreed with this view. Lusby of IRH Industries and Whitton of ICI were both of the opinion that CSIRO divisional chiefs had too much autonomy in the choice of research to be undertaken and therefore chose projects which would yield results publishable in high-status international journals.[49] Ward of BHP said that continuous contact was necessary with 'customers' for research and that it was therefore not surprising that researchers who perceived that their role was confined to the laboratory would be frustrated at industrialists' lack of interest in their results.[50] Davies of AWA agreed that when scientists eventually communicate with industry it is too late for effective input of development needs.[51] There seems to have been a gross lack of communication between the senior scientists in CSIRO and their 'customers' in manufacturing industry which did not occur in rural industry.

Here, once again in the history of science policy in Australia the policy analyst is struck by the dichotomy between the relationships between researchers and rural producers and researchers and non-rural producers. White's argument was that:

> In agriculture there are a very large number of individual farmers and pastoralists to whom it is important to convey new discoveries promptly....On the industrial side the position is different, for here we are dealing with individual firms. Each firm, depending on the nature of its activities and its production, wishes information specific to its interests. It is for example, not of much interest to a cement manufacturer to have news of scientific discoveries of importance to the pulp and paper industry.[52]

One can speculate that pig farmers equally would not be very interested in wheat production. The same environmental variables seem to have evoked different responses in different sectors of the CSIRO subgovernment. In rural production research results were widely broadcast and it was the responsibility of the levy-paying producer to use the results productively. In non-rural industry the knowledge produced by the researcher was considered to be the private property either of CSIRO or the producer.

There would appear to be a closer fit between the norms of science about the universality of knowledge and the nature of the relationship between government and rural producers in Australia, than that between science and the non-rural industrial sector. The reason arguably lies in the fact that, in the mid-1960s, government intervention and sponsorship were much better developed in rural industry because of

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48 Ibid., p.161, discussion on White's paper.
49 Lusby, 'Science Policy towards the Electronics Industry', p. 143.
50 Ward, 'Science and Industry', p. 374.
51 Davies, 'Federal Policy for Industrial Research And Development in Australia', p. 425.
52 White, 'Administration of Scientific Reseach', pp. 124-125.

the political influence of the rural lobby. Rural techno-economism was legitimate but non-rural techno-economism was not. The same opposition to intervention was evident in rural industry when vested interests were threatened, as we saw in relation to the prohibition of work on man-made fibres by the wool research association. At that time too, whole divisions of CSIRO were more or less dependent on rural research funding.[53] Political ideology, scientific ideology and resource needs coincided to produce a different pattern of knowledge dissemination for rural research from manufacturing research.

4.3 The application of research results, 1990

The 1977 Independent Inquiry into CSIRO considered at some length the issues of the dissemination of and commercialisation of research results and recommended that responsibility for the development of results should be conferred onto individual researchers, and that the responsibility for effective patenting, licensing and the negotiation of joint ventures should be the responsibility of the Organisation in general and Divisions and Institutes in particular.[54] In early 1985 the Organisation set up Sirotech as an independent company to manage the technological transfer and commercial assesment aspects of CSIRO research. In addition Sirotech would canvass the research needs of industry.[55]

However, this initiative may have been too late because in 1985 ASTEC found: '... that CSIRO may not have been sufficiently vigourous in pursuing the commercial application of its work'.[56] ASTEC acknowledged that there were many areas of CSIRO research, such as climate changes and the formation of ore deposits, which may not have patentable results even twenty years hence. Nevertheless, in order to provide economic returns to society, it was essential that researchers should be continually aware of which aspects of their work could be commercialised. In order to encourage this awareness, individual researchers and their Divisions should be rewarded by being allowed to retain the royalties from such work. These measures were endorsed by the then Minister for Science, Barry Jones, and between 1986 and 1989 were built into the re-structuring of the Organisation.[57]

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53 For example, in 1965 the divisions of Animal Physiology, Protein Chemistry and Wool Research were totally funded by contributions.
CSIRO *Eighteenth Annual Report,* pp. 208-213.

54 Australia, *Independent Inquiry into CSIRO*, pp. li-liii.

55 J.P. Wild, 'CSIRO and the ASTEC Review', *Search,* vol. 16, no. 5-6, June-July 1985, pp. 124-126, p. 125.

56 ASTEC, *Future Direction for CSIRO,* p. 33.

57 Mayo, Chief of the Division of Animal Production, reports that the bonus and incentives scheme was introduced aginst the wishes of researchers. Details of the scheme were sent to the divisions for comment which was almost universally hostile. Nevertheless, the scheme was introduced in its original form and consequently was resisted by the scientists who see it as counter to the traditional understanding of collective credit for work accomplished. Much scientific work is the result of input from a widely disparate set of researchers. The incentive sheme is based on a few people taking credit for new knowledge.
Mayo, Interview, 7.11.89.

By 1987 Sirotech had negotiated the establishment of three new companies jointly with ICI, Du Pont and the Australian Mineral Development Laboratories. The company had arranged twenty collaborative agreements and advised on 200 more. The number of patents filed almost tripled from 43 in 1983, to 73 in 1985 and 123 in 1986-87. The company also arranged for over 800 patent applications to lapse, indicating the extent to which patent administration had been neglected by the Organisation.[58] However in 1992 it was announced that the company would be abolished and its functions taken over by individual divisions as suggested in the Birch Report in 1977.

Responsibility for knowledge application now resides in the divisions. Their annual reports show that evidence of collaboration is now part of the reporting process. For example, the Annual Report of the Division of Geomechanics listed 102 collaborators in 1990. 56 of these were private companies.[59] The Division of Polymers and Chemicals, which has a long history of collaboration with industry and patenting of its research findings, published in its 1990 Annual Report a list of confidential internal reports, adding in parenthesis that: 'This list is published solely to indicate the extent of the Division's collaboration with industry'.[60] The Divisions have always included summaries of industry collaboration in their Annual Reports, what has changed is the number of collaborations and their importance in divisional funding and priorities.

Summary: CSIRO

The above changes in the pattern of the dissemination of new scientific knowledge did not occur 'naturally' as scientists observed a sudden need to fulfill government and industry's expectations. It required a deliberate governmental fracturing of the patterns of interaction established by scientists to suit their ideological and resource needs. Only when resource allocations were changed, when statutory obligations were re-emphasised, and when new ideas about the dissemination of research results were imposed on the Organisation did scientists begin to orient their work to industry as well as the international scientific community; and to manufacturing as well as rural industry's needs.

5. Manufacturing Industry

There are several indicators which can be used to analyse the manufacturing sector in terms of the scientific knowledge produced and its application. The level of business expenditure on research and development (BERD), and the level of government support of industrial research and development through grants and tax concessions are

58 CSIRO *Annual Report 1986-87,* p. 41.
59 CSIRO Division of Geomechanics, *Annual Report 1990-91,* CSIRO, Canberra, 1991, p. 40.
60 CSIRO Division of Chemicals and Polymers, *Annual Report 1990-91,* CSIRO, Canberra, 1991, p. 18.

direct measures of research activity which have been examined in chapter five and are shown to have increased dramatically in the 1980s. The level of payments for know-how and royalties, and the level of patent activity are other indirect measures of inventiveness and these are examined here. Only 3 per cent of patent activity occurs in the area of agriculture, and so patent statistics can largely be seen as a measurement of manufacturing activity.

Intuitively the causal pathway would seem to be that, as the level of BERD rises, the level of patent activity should follow and that of payments for know-how should decrease. However, the relationship is much more complex than this with such factors as the availability of venture capital, the way in which technology is transferred between overseas firms and their Australian subsidiaries, and the effects of government policy on the importation of technology, intervening to change the direct nature of the interaction. The relationship between expenditure on research and development and patent activity should therefore be seen as a general rather than an absolute indicator of inventive activity. Nevertheless patent activity continues to be used as a measure of the effectiveness of expenditure on research and development.[61]

5.3 Patterns of patent activity

In the mid-1960s patent statistics were beginning to be used as a direct indicator of the effects of new products and processes on economic growth and as an indirect indicator of the effectiveness of scientific research activity on the processes of economic production. In 1966 Encel and Inglis analysed patent activity in Australia and found that, in common with most small economies, the level of domestic patent activity was in decline and that of foreign patents lodged in Australia was increasing. For example, in 1961 67 per cent of patent applications in Australia were from overseas compared with 55 per cent in 1951.[62] Figure 8.4 shows the level of patent activity in the non-rural and non-mining sectors between 1965 and 1990. The sharp rise between 1965 and 1972 is probably due to changes in the classification system.[63] The data shows that patent activity in Australia in 1990, although having doubled since 1981, has not yet reached the level of 1973.

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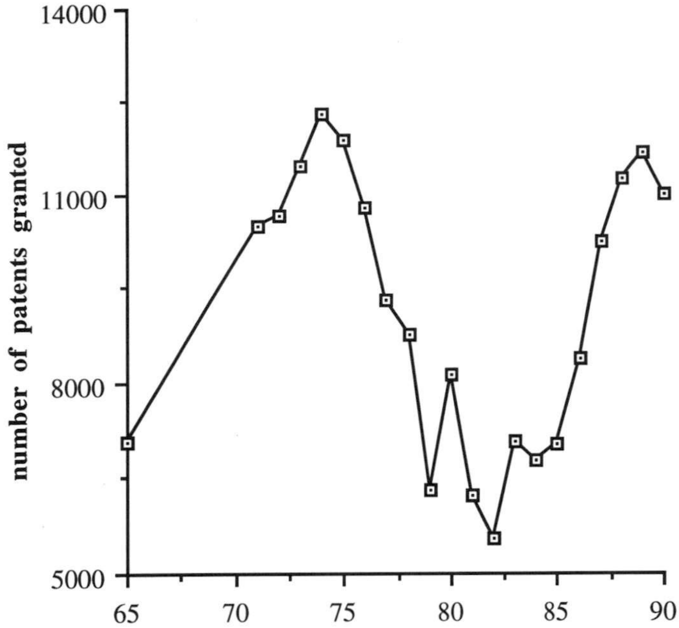
61 DITAC have included patent activity as as a science and technology indicator in its *Australian Science and Innovation Resources Brief* since 1987.

62 Encel & Inglis, 'Patents, Inventions and Economic Progress', p. 578.

63 The Patents Office has only been issuing annual Activities Reports since 1974. World Intellectual Property Organisation data for the previous years are supplied by the Patents Office but the categories altered slightly in the late 1960s from the later IPC scheme.
Steven McMillan, Program Development Branch, Australian Patent, Trade Marks and Designs Offices, Canberra, Personal Communication, 16.11.92.

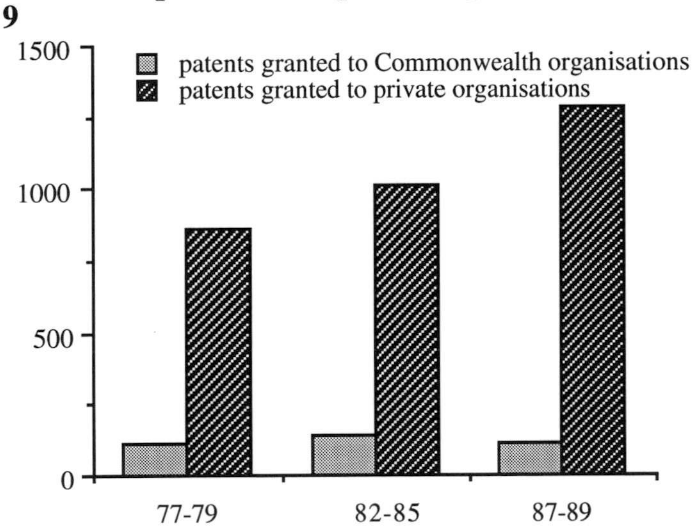
Figure 8.4: Patent activity in manufacturing production, 1965-1990



Data source: Australian Patent, Trade Marks and Design Offices, Activities Reports 1974-1990; Stephen McMillan, Program Development Branch, Australian Patent, Trade Marks and Design Offices, Personal Communication, 16.11.92

As might be expected, most patent activity occurs in the private business sector. Figure 8.5 illustrates the changing sectoral level of patent activity between 1977 and 1989.

Figure 8.5: A comparison of patents granted to sectors of industry 1977-1989



Data source: Australian Bureau of Statistics, *Research and Experimental Development: All Sector Summary 1977-79,* Cat. No. 8112.0, 1985, Table 12, p. 9.
Australian Bureau of Statistics, *Research and Experimental Development: All Sector Summary 1984-85,* Cat. No. 8112.0, 1987, Table 25, p. 21.
Australian Bureau of Statistics, *Research and Experimental Development: All Sector Summary 1988-89,* Cat. No. 8112.0, 1990, Table 20, p. 17.

The annual average level of patents granted to private sector enterprises increased by 49 per cent whereas the level granted to Commonwealth Government organisations rose by only 0.03 per cent. The increase was highest between 1982-85 and 1987-89 when the number of patents granted to industry rose by 27 per cent.[64]

However, since 1967 Commonwealth governments have subsidised manufacturing research through the industrial research and development (IR&D) schemes. Figures 8.6 and 8.7 illustrate the relationship between IR&D grants and patent applications. The data consist of the annual number of patent applicants domiciled in Australia (available only since 1974), the annual number of patents sealed, and the levels of IR&D grants deflated to 1990 level.[65] All the data are smoothed as three-year moving averages to clarify overall trend.

There is a ten-year lag between levels of IR&D grants and patent applications. The high point in grant expenditure in 1972-73 is matched by a high point in patent applications in 1982-83. Grant expenditure fell in real terms between 1976-82 and applications fell in 1985. Since 1984 the level of grant expenditure has fallen sharply but the number of patent applications has remained fairly constant. This would seem to indicate that the tax concession, introduced in 1986, has now superceded the IR&D grant as the preferred form of funding inventive activity. In comparison the relationship between the commercialistion of research is not so closely correlated. The level of patents sealed dropped dramatically during the recession of the early 1980s but continued to rise as the real level of IR&D grants fell after 1984.

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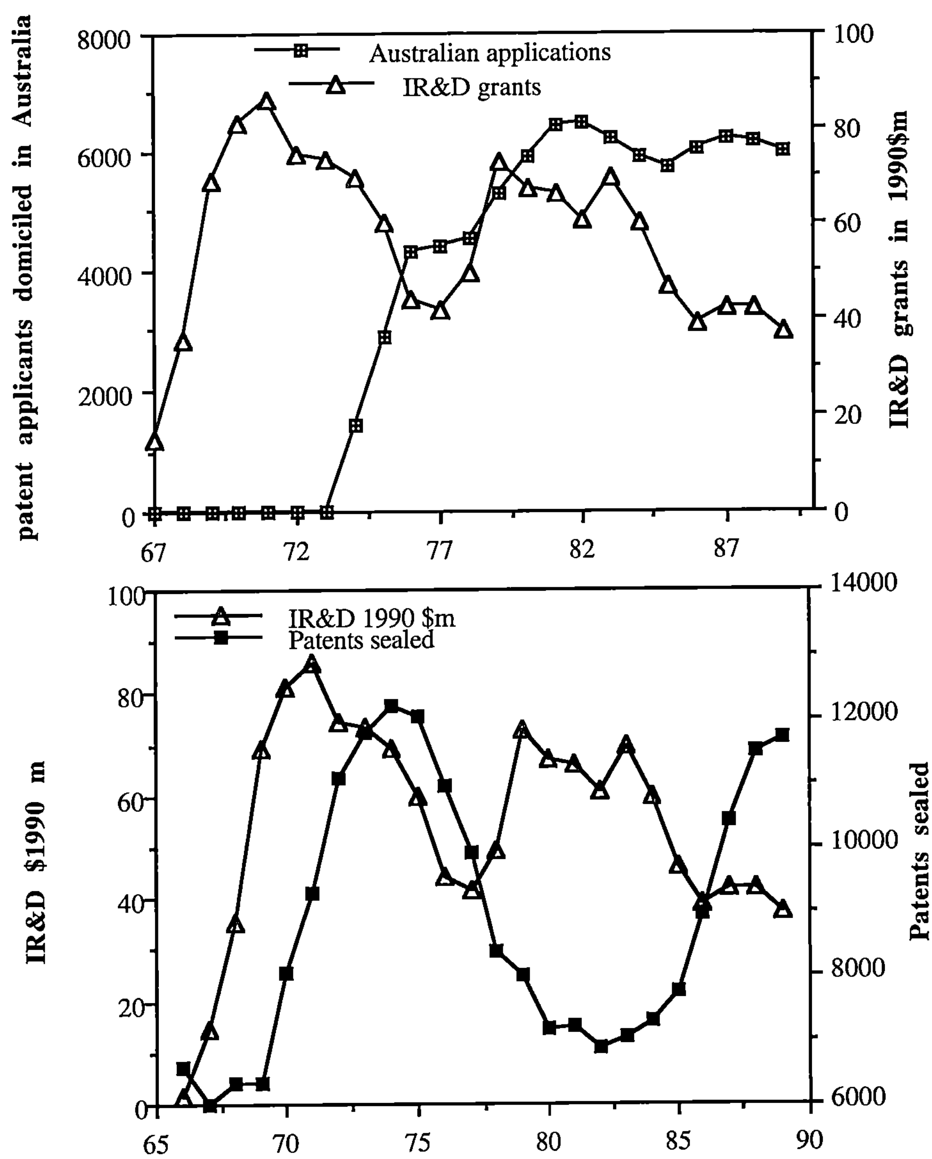
64 The ABS collects patent data on a sectoral basis on an intermittent basis only as funding permits Consequently the period of time for each set of data differs. The 1977-79 and 1987-89 data represent two years of activity and the 1982-85 data represents three years of activity. To compensate for this discrepancy the data for Table 8.5 has been averaged.
Derek Byars, ABS, Canberra, Personal Communication, 13.11.92.

65 Australian domicile does not necessarily indicate Australian ownership.

Figure 8.6 & 8.7: the relationship between Australian patent applications, IR&D grants and patents sealed, 1965-1990.



Data source:	Stephen McMillan, Australian Patent, Trade Marks and Designs Offices, Canberra, Personal Communication, 16. 11. 92; Australian Patent, Trade Marks and Designs Offices, *Activities Report* 1974-1990; AIRDS Board, *Annual Report,* 1967-1976; AIRDIS Board, *Annual Report,* 1976-1985; IR&D Board, *Annual Report,* 1986-1991.

One aspect of patent activity which is increasingly cited as an indicator of economic innovation by the private business sector is the number of overseas patents applied for by Australian firms. An increase in the level of overseas patents would indicate that Australian firms are intending to export the products of innovative activity rather than simply replacing imports.[66] The OECD measures such patent activity as numbers of external patent applications per unit of GDP. Between 1981 and 1989 the

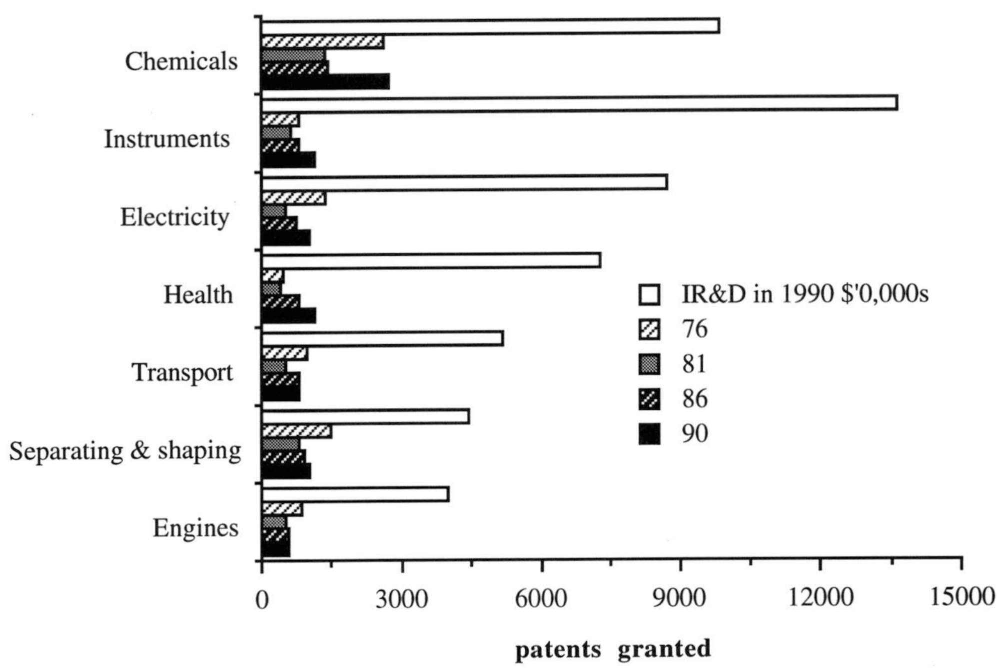
[66] DITAC, *Measures of Science and Innovation,* p. 212.

number of external patent applications from Australian residents rose from 2.7 to 6.1 per GDP unit, giving Australia the highest such growth rate in the OECD.[67]

5.4 Changes in the sectoral distribution of patent activity

The areas of manufacturing represented in Figure 8.7 are the seven most consistently active in terms of granted patents. The industrial research and development expenditure illustrated consists of the estimated sum total of research grants to industry between 1976 and 1990, and is represented on the graph by the white bar.[68] The other bars represent annual patent activity.

Figure 8.7: The relationship between IR&D grants and patents in the seven most active international patent classification areas, 1976-1990



Data source: IR&D Board Annual Reports, 1976-1990.
Australian Patent, Trade Marks and Design Offices, Activities Reports 1974-1990.

The chemicals category is consistently the area in which the most patents are granted. It covers such areas as dyes, ceramics, waste water treatment and the fermentation industry which has traditionally been awarded the highest grants within the category. In real terms the peak funding years were 1980 and 1987. The instruments category, which has received the greatest grant allocation over the period, has a relatively low

67 DITAC, *Australian Science and Innovation Resources Brief 1992,* p. 12.

68 The data does not include tax concessions. The data for grants between 1965 and 1976, and for the research and development tax concession are classified according to the Australian Standard Industry Classification (ASIC) scheme rather than the IPC scheme used for patents and discretionary grants. Consequently, only the expenditure data on commencement, project and discretionary grants is comparable with the patent data. The expenditure figures are totals of amounts given in Annual Reports and therefore must be considered only as an estimate. McMillan, Personal Communication, 16.11.92

outcome in terms of patents. The peak grants for this area occurred in real terms in 1983 and 1984 and were awarded to the computer industry. Given the lag between research and patents it may be that this area will show more patent activity in the early 1990s. The 'separating and shaping' category is an aggregate of two categories which include such industrial activity as physical and chemical processing of natural substances and the working of materials into products in plastics, metal and minerals. The category produces a relatively high level of patents but receives a low level of industrial research grants. In all areas except health and instruments the highest levels of patent activity occurred from 1972 to 1976 and then again from 1987.

Patent activity since 1986 has been static in the traditional manufacturing areas of transport and engines and shows the greatest increase in the areas of chemicals, health and instruments which cover the 'new' industries of ceramics, biotechnology, and computers.[69] However, it is unlikely that any definite conclusion can be drawn about the relationship between government intervention and patent activity until the mid 1990s. The tax concession scheme will then have been in existence for ten years and the effects should be showing in patent statistics. It should then be possible to compare the differential effects of grants and tacx concessions to assess the effectiveness of government priorities for manufacturing research in terms of commercialisation.

5.5 Changes in technical know-how payments and receipts

Technical know-how is the specialised knowledge in the form of scientific, technical or engineering expertise which is needed to produce a product or implement a process. Technical know-how is acquired by transfer in kind, through the purchase of patent licences or through royalty payments.[70] The majority (89 per cent) of this knowledge is used in the manufacturing sector.[71] Australia imports technical know-how to the value of $300 million a year and exports a much lower level of knowledge. However, the balance of technical know-how payments and receipts is changing. Table 8.1 shows the changes between 1978 and 1989.[72]

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69 Patent statistics are given only in the broad category levels used in the figure but industrial research grant statistics are broken down into sub-categories.

70 ABS, *Research and Experimental Development: All Sector Summary 1989-90,* Cat no. 8112.0, AGPS, Canberra, 1990, p. 25.

71 DITAC, *Measures of Science and Innovation, 1987, p. 277.*

72 Surveys of technical know-how payments and receipts are undertaken by the ABS on a similar ad hoc basis to patent data surveys, i.e., when the Bureau is requested to do so and funds are made available. The first such survey was in 1978-79.

Table 8.1: Australia's changing balance of payments for technical know-how, 1978-1979, in 1990 $m

Year	*Payments*	*Receipts*
78-79	324	38.3
ratio	**8.5**	**1**
84-85	224.5	50.2
ratio	**4.5**	**1**
% change	*31%*	*31%*
88-89	377.3	139
ratio	**2.7**	**1**
% change	*68%*	*177%*

Data source: ABS, *Research and Experimental Development: All Sector Summary*, 1978-79, p. 9.
Research and Experimental Development: All Sector Summary, 1984-85, p. 21.
Research and Experimental Development: All Sector Summary, 1988-89, p. 15.

In 1978-79 payments outweighed receipts by 8.5 to 1. In 1984-85 the payments decreased by 31 per cent due either to less production or to the fact that production relied less on overseas technical know-how, or a combination of both scenarios. However, in that year receipts increased by 31 per cent indicating that more Australian technical know-how was being used in overseas production. The ratio of payments to receipts in this year was 4.5:1. By 1988-89 technical know-how payments had increased by 68 per cent but receipts increased by a massive 177 per cent which reduced the payments to receipts ratio to 2.7:1.

These changes in the technical know-how balance of payments, taken with the level of patent activity, the growth in the number of Australian innovations patented overseas, and the sectoral distribution of patent activity, as well as the increased level of BERD demonstrated in chapter five, indicate that the late 1980s has been a time of considerable inventive activity and innovation in the non-rural sector of production in Australia. Because of the lag between research and development activity and the commercialistion of products and processes it is as yet too early to determine exactly how effective the changes in science policy have been but the indicators to date would seem to point to considerable increases in innovative activity in Australian manufacturing industry.

Summary: manufacturing industry

Changing patterns in the the knowledge created for manufacturing industry by research and development can be traced through patents and through know how payments. These indicators show that there has been an increase in the amount of knowledge patented in Australia and an decrease in the payments made by manufacturers in Australia for the use of knowledge created overseas. These changes, together with the increasing levels of BERD since 1983 indicate that manufacturing industry in Australia is funding, and using in production, an increasing amount of scientific knowedge.

6. Rural Industry

Perhaps the greatest change has taken place in the type of knowledge produced and the mode of its dissemination in rural research. In 1965 the knowledge produced by research agencies for use in rural production was to a large extent considered by governments, researchers and producers as a public good. The knowledge was disseminated to national rural producers through government-funded extension services. In 1990 rural research is increasingly seen as a private good. Between 1986 and 1990 the Commonwealth Government committed $14.5 million to joint venture research in biotechnology involving private companies.[73]

6.1 Rural research knowledge and its application in 1965

In 1965 Commonwealth and State Governments subsidised both the production of research for rural production and the extension services by which the knowledge was disseminated to the producers. Of the research undertaken by CSIRO in 1965 and paid for through budget appropriations, 38 per cent was for rural research. CSIRO also had an Agricultural Liaison Unit which, through such means as technical conferences, specialist committees, publications and personal contact, interacted with producers to disseminate knowledge of new processes, and to help solve production problems. Some knowledge was developed to the stage where it could be used directly by extension officers and this was published in the quarterly *Rural Research in CSIRO* or transmitted by direct interaction with State Departments of Agriculture.[74]

In the universities at least 34 per cent of ARGS grants were for research connected with rural production.[75] In addition the Commonwealth Government, through Special Purpose Grants and Special Appropriations, contributed to such programs as:

- dairy industry extension services;
- agricultural advisory services;
- tobacco industry extension services;
- cattle tick control and research;
- tuberculosis and brucellosis eradication.

Most of these services were also supplied through the extension programs of State Departments of Agriculture. In 1968-69, 72 per cent of research expenditure funded directly by the States was for agricultural science.[76] Knowledge funded by all these means was intended to keep farmers in touch with advances in research which affected

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73 IR&D Board, *Annual Reports*, 1986-1990.

74 CSIRO *Eighteenth Annual Report*, pp. 106-107.

75 For these grants and for CSIRO funds it is difficult to separate disciplinary and divisional resources into precise categories. Only research directly identified with rural production is included here but in many instances such research as cloud seeding in Atmospheric Physics, land use degredation studies in Environmental Mechanics, insect venom attractants and repellants in grants for Chemistry, are obviously for use in rural production .
ARGC, *First Report*, pp. 577-589.
CSIRO *Eighteenth Annual Report*, pp. 118-165.

76 Department of Science, *Project SCORE*, Report 2, Research and Development Expenditure by State Governments, pp. 5 & 26.

their special production needs of regional variations in such factors as soil fertility, pests and diseases and plant variations.

This type of interaction suited both political and scientific ideologies. The political influence of the National Country Party and the fact that many Liberal politicians were themselves rural producers meant that political will matched influential private interests.[77] As Marsden notes:

> Both politicians and research managers recognize and take into account the beneficial consequences of research on the income of particular communities or interest groups and, as already noted in relation to irrigation projects, where the benefits are concentrated but the costs are spread over many individuals, projects tend to receive public funding more readily.[78]

Members of State and Commonwealth Parliaments could help their constituents and themselves by establishing and then by protecting such services from detailed analysis. The electoral consequences of withdrawing such services would be localised and so the services survived the more general cuts to rural subsidies of the Whitlam Government. The collective, uncommercialised nature of the dissemination of research results also conformed with scientists' notions of the communality and disinterestedness. The state paid their salaries and the producers collectively benefited from their work. The Australian community indirectly benefited through high export commodity prices and lower production costs. It was not until economic recession both lowered rural commodity prices and restricted the flow of resources to science that the relationship came under scrutiny in the early 1980s. At the same time, advances in biotechnology, or the manipulation of genetic material in life forms, heralded the dawn of a new era in which governmental and private interests would coincide in different ways in rural production.

6.2 Rural research in 1990: the biotechnology revolution

The revolution in biology was recently described in *The Economist* thus:

> In the 1950s [the biologists] found that heredity was controlled by a simple code written in DNA. In the 1960s they cracked the cipher. In the 1970s they found out how to insert new genes in the codes of bacteria. In the 1980s they did so, and built an industry whose promise of abundant drugs, new-fangled crops and environment-cleansing bacteria may yet be fulfilled in the 1990s.[79]

In 1965 the word 'biotechnology' did not appear in CSIRO's Annual Report (which contained a list of all published papers).[80] By 1990 Professor Adrienne Clarke of the

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77 The Minister for Education and Science in 1969 was Malcolm Fraser, a grazier from Victoria's Western Districts.

78 Marsden et. al., *Returns on Australian Agricultural Research,* p. 15.

79 'Biology's heyday', *The Economist,* February 16 1991, Science Survey, pp. 6-7.

80 Biotechnology is 'the application of scientific and engineering principles to the processing of materials by biological agents to provide goods and services'. It includes such technologies as: genetic engineering; cell manipulation and culture; fermentation technology and enzyme technology.

Special Research Centre for Plant Cell Biology at the University of Melbourne was inventing new plants using such techniques.[81] Advances in biotechnology have far-reaching implications for the production and dissemination of new knowledge in rural production, and therefore for governments and scientists. CSIRO and university laboratories in Australia have been at the forefront of the use of genetic manipulation in rural production. Plants, animals, pests and fertilisers can be tailored to suit producers' requirements. Because of the appropriability of the new knowledge in the form of patents, large firms involved in rural production are now much more involved in the relationship between researchers and producers. Universities and CSIRO are receiving private funding for research in biotechnology, the results of which will not flow directly to producers but will need to be purchased through products, patents, licences and royalties on the use of intellectual property.

In terms of research output, fields of rural science form the sub-group Biology II of the Computer Horizons Inc. database on scientific papers and citations. The group includes agricultural, food, veterinary, dairy and animal sciences, entomology and parasitology. This is the most internationally successful of all fields of science in Australia. As we have seen, scientific papers from Australia consistently form two per cent of the world's scientific papers. For the five areas in Biology II both output and citation percentages in 1975, 1980 and 1984 were consistently higher than two percent. Agricultural and food science reached over four per cent each year, and veterinary medicine was over six per cent for the period.[82] Between 1981 and 1992 the two categories of plant and animal sciences, and agricultural science comprised 20 per cent of all Australian papers published and documented by the Institute of Scietific Information in Philadelphia.[83]

Successive governments have realised the potential of this research strength. Biotechnology was identified in 1980 by the Senate Standing Committee on Technological Change (the Myers Committee) as one of six generic technologies of potential benefit in Australia. Initiatives by the Fraser Government such as the convening of a symposium in 1981, the commissioning of an ASTEC report in 1982 and the National Biotechnology Workshop also in 1982, were continued by the Hawke Government.[84] Biotechnology was one of the first generic technologies prioritised under the new GIRD scheme in 1986. Plant and animal biotechnological research is the focus of three Special Research Centres in universities. Of the 52 Co-operative Research Centres established in the first two rounds of funding 18 are

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ASTEC, *Biotechnology in Australia,* AGPS, Canberra, 1982, p. 4,

81 Adrienne Clark, 'New plants for old', *The Uncertainty Principle,* Robyn Williams (ed.), ABC Enterprises, Sydney, 1989, pp. 205-217.

82 Entomology fell to 1.8% in 1980 but recovered with 2.75% in 1984. ASTEC, *Profile of Australian Science,* pp. 255-257.

83 Bourke & Butler, 'Australian Science: "Some Worries, Mate"', p. 9.

84 ASTEC, *Setting Directions for Australian Research,* p. 22.

connected with rural research and include centres of biotechnological research for agriculture. In 1990 the proportion of papers published by CSIRO in plant and animal biology was 51 per cent - the highest ever level.[85]

The way in which this knowledge is being disseminated is in flux. There has been what Dickson calls a 'structural shift' in interactions between governments, private industry and researchers. The fact that most biotechnological research would be classified as basic science has meant that large private companies are now interested in sponsoring basic, as opposed to applied research in universities.[86] In Australia much of this research would formerly have been disseminated in applied form through the publicly-funded extension services. So far the extension services remain, though State Departments of Agriculture are cutting back on research laboratories as private funding increases. The Chief Executive of CSIRO recently felt the need to reassure farmers of continuing support in face of the shift to research into value-added processes.[87]

The reason is that firms see biotechnological advances and value-added processes as research which can be appropriated for private profit rather than collective benefit. This fits a Commonwealth government science policy advocating more external funding for public sector research agencies. The problem for rural producers is the shortfall in available knowledge. Where this is produced by direct funding from research councils and corporations there is little change in the application of results. For example, the Wheat Research Council's Five Year Research and Development Plan includes an ongoing assessment of the measures used to incorporate research results into producers' practices.[88] The corporatisation of the research councils means that the producers themselves will have the opportunity of selling and licensing the intellectual property which results from the research they fund.[89]

The question of intellectual property in rural research was the subject of much debate in the mid-1980s as the Commonwealth government was proposing the introduction of plant variety rights. The subject arouses considerable passion and is an ongoing issue for science policy-makers because the patentability of altered genes changes the interactions of rural research.[90] Proponents argue that the lack of protection means that growers in Australia are denied the use of new varieties because

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85 Sunter, Personal Communication, 30.11.92

86 David Dickson, *The New Politics of Science,* University of Chicago Press, USA, 1989, p. 77.

87 'CSIRO pledges to help farmers', p. 4.

88 Wheat Research Council, *Annual Report 1988-89,* Parl. Papers no. 34 of 1990, p. 3.

89 Peter Sheehan, 'Commercialising Science - the Government viewpoint', in *Innovating Our Way Out of the Rural Crisis,* eds. C.D. Kimpton & L.W. Martinelli Royal Society of Victoria/Australian Institute of Agricultural Science, 1987, pp. 59-65, p.65.
Paul Donnelly & Stuart Gray, 'What is the role of the Dairy Research and Development Corporation in the Dairy Industry?', *Agricultural Science,* New Series, vol. 4, no. 3, May 1991, pp. 39-41, p. 40.

90 Plant variety rights differ slightly from patents in that only the end product is protected and not the product.
Anon, 'Plant variety rights in Australia', p. 291.

the overseas owners would not benefit through royalties. Opponents argue that the capacity to buy rights to new varieties would enable multi-national petro-chemical companies to withold pest-resistant plants from the market or bind them into genetic dependence on the manufacturers' products.[91]

In fact patenting does not 'lock away' research information but requires the user of the knowledge to pay the researcher or the holder of the patent for the right to use the information. Such information is usually available six to twelve months after the patent has been applied for.[92] Since 1990 Australia has had a patent system similar to most of those in Europe and Japan, and through which a provisional patent can be issued at relatively low cost. This proves priority while researchers, owners and investors assess the commerciability of the knowledge. Professor Adrienne Clark, now Chair of CSIRO, believes that the research community in Australia is gradually becoming used to the idea that their findings must be protected before they are aired at conferences or in journals. She says that when the shift to patenting began both patent attorneys and scientists had trouble with each other's perception's of priorities. Now they, and the investing companies, are much more realistic about accommodating everyone's interests into intellectual property agreements.[93]

6.3 Summary: rural research application

The trend in the application of rural research results from a system based on the publicly-funded dissemination of knowledge to one based on the privatisation of intellectual property is one which holds challenges for the science policy community. The role of the Commonwealth and State governments is changing from one of being the major source of funds to one of refereeing the process of knowledge transfer. Governments now have a major responsibility to ensure that the Australian community gains maximum financial and social benefits from the knowledge produced by public funds.

Having created a climate in which private firms are encouraged to participate in the research process, and in which researchers must seek international scientific status through the marketplace as much as through scientific journals and conferences, the role of governments is increasingly becoming one of facilitator of the process of negotiation over intellectual property. Once more the rural science policy subgovernment has taken the lead in the Australian science policy community by enabling the members of the rural science subsystem to gain the necessary knowledge and skills to protect their interests. This is happening through workshops and symposia where producers, financiers, patent attorneys and rural research corporation managers can interact and exchange views and skills. Governments will also need to

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91 Robert Bell, 'The case against plant patenting', *Search,* vol. 16, no. 9-12, pp. 298-299, p. 298.

92 Robert Klupacs, 'The Power of the Patent', *Today's Life Science,* vol. 1, no. 3, September 1989, pp. 14-16 & 19.

93 Adrienne Clark, 'New plants for old', p. 216.

ensure that the licence and royalty agreements entered into by public research institutions bring optimal, long-term benefits for the whole of the Australian community. In this way the privatisation of rural research can benefit, rather than disadvantage, rural producers in particular and the Australian taxpayer in general.

CONCLUSION

This final chapter on the outcomes of the transition in science policy between 1965 and 1990 has demonstrated the way in which the knowledge produced in the science system in Australia has changed as a result of the techno-economistic ideology of the ALP governments since 1983.

In the higher education sector the knowledge produced is increasingly seen as the intellectual property either of the scientist, the university, or the industrial partner sponsoring research. The direct challenge to the norm of disinterestedness has created conflict for those scientists who still seek to uphold the norms.

In CSIRO there was a traditional understanding that the knowledge produced by the organisation was a public good to be disseminated locally through interaction with rural and manufacturing industry; and outside Australia through the publication system of the international scientific community. This has changed as government forced the Organisation to align its research towards innovation and commercialistation.

The manufacturing sector in Autralia, through foreign ownership, and trade protection, has not perceived research and development as an integral part of economic production. It has required considerable government intervention to change this culture, but patent, know-how and BERD indicators show a marked change towards a more knowledge-based manufacturing sector.

Finally, and paradoxically the greatest changes in the production and application of scientific knowledge in Australian economic production seem to be occurring in the rural sector, where research and development has traditionally been funded collectively, valued and systematically applied to production. The dynamic for change has come equally from the enormously challenging field of biotechnology, and from a government wishing to make Australian rural production less vulnerable to the volatility of commodity prices. Rural research has always been at the forefront of science policy in Australia. It is fitting that this sector should be demonstrating the possible future role of government in its relationship with the scientific community - that of ensuring that the Australian community reaps the full benefits of the public funding of the creation of new scientific knowledge by acting as the facilitator of the intellectual property trade.

CONCLUSION

This study establishes that, between 1965 and 1990, there has been a radical shift in the objectives of science policy in Australia, and the way in which governments have sought to realise these objectives. These findings emerge from the above analysis of the patterns of change in the formulation, articulation and implementation of science policy. Such changes reflect the exercise of power, through control over rules, resources and ideas, in the relationship between governments and scientists; and the way in which power is linked to the value systems which underlie interaction between political and scientific actors. The study therefore links policy changes directly with political and scientific ideology, and with the global economic imperatives which challenge these ideologies and have also driven major policy changes in other areas of policy such as the removal of tariff protection in manufacturing industry.

The policy impact of the interaction between science and politics has received scant attention in Australia and this study begins to address how conflicting or complementary value systems affect the formulation, evaluation and implementation of science policy. The policy community approach is the particular vehicle employed to analyse the ways in which these values are articulated in the interaction and expressed as the exercise of power. Therefore this final chapter assesses the utility of the policy community approach and the refinements to it which have developed in the course of this analysis.

The chapter also reviews the changing patterns of interaction in the science policy community, summarises the explanations of change, proposes a taxonomy of science policy based on the relationship between government objectives for science and the way in which they are achieved, and speculates on how the patterns identified between 1965 and 1990 may extrapolate into the twenty first century.

1. THE POLICY COMMUNITY APPROACH

The policy community approach used in this thesis follows the work of Pross (1986) and Coleman and Skogstad (1990), and incorporates some of the suggestions made by Atkinson and Coleman (1991) on how further studies would be able to clarify and refine the approach. The approach is used here for several reasons Firstly, the approach focuses on the actions and interactions of significant policy actors and therefore fits well the realities of science policy as an area of government activity which crosses many functional boundaries including rural, health and manufacturing research.

Secondly, the fact that the policy community approach also spans the divide between public and private arenas of social activity is of particular use in the science policy arena because the boundary between public and private research and development in Australia has always been hazy. Using the approach in chapter four was very helpful in identifying and explaining, for example, the membership and activities of the rural research trust fund advisory committees which, despite their title, actually exercised considerable power in decision-making about the allocation of resources in rural research.

Thirdly, the basic analytical distinction between two categories of: (1) the subgovernment and (2) the attentive public, introduced by Pross, successfully separates actors who actually make significant decisions from those who simply influence such decisions. It is therefore a catalyst in recognising which actors are excluded from routine decision-making. This is particularly useful in longitudinal policy studies because the movement of individuals in and out of the subgovernment identifies changing patterns of resource dependencies and ideas.

Fourthly, the approach can analyse action in policy arenas that have low electoral impact and therefore are not usually widely debated in, or affected by decisions in the more visible institutions of the political system. Science policy until the 1980s was just such an arena in which the subgovernment and influential members of the attentive public kept decision making very much within small networks of interaction.

Fifthly, the approach implicitly recognises the impact of significant actors beyond national boundaries. This is of particular use in the analysis of science policy because of the close integration of domestic and international scientific communities. For example, failure to recognise the importance of the OECD in spreading the doctrine of techno-economism; or failure to recognise the capacity of governments to use OECD endorsement as a means of legitimating policy change, would overlook an important element in science policy-making. This aspect of policy communities is discussed in greater detail below.

Sixthly, Pross's notion of pressure groups as the agents of change can explain the rise and fall in the degree of influence exerted by these groups through time. This concept allows the analyst to identify the role of such groups as the Australian Academy of Science in the 1950s and 1960s, of AATSE in the late 1970s, and FASTS, NSTAG and ASA in the 1980s. It also elucidates the demise and reformation of pressure groups in the science policy community as the importance of their ideas and their policy salience wax and wane through time. An example of this phenomenon is the incorporation of FASTS into the Budget scrutiny process in 1985, and its fall from grace in 1993 when it espoused an ideology in conflict with that of the superstructural subgovernment

Finally, Coleman and Skogstad's categorisation of different types of policy network interaction has been particularly useful in discerning and identifying patterns of interaction through time in the Australian science policy community. The traditional patterns of interaction were generally *clientele pluralist* (see table 4.2). This category of network is one in which state interests are dependent on the skills, information and commitment of weakly associated organised interests in the formulation and implementation of policy. In chapter four the discussion of the structure of the science policy community in the 1960s demonstrates the way in which the science policy subgovernment was very dependent on the participation of elite actors in the higher education sector and CSIRO. In the manufacturing sector of science policy at this time the networks were of the *pressure pluralist* type in which a few weakly associated interest groups were engaged only in policy advocacy through the Australian Industry Research Group. This contrasts with the situation in the rural research sector which was strongly *corporatist* in nature. In this sector, producer interest groups and the state combined in permanent agencies (the committees of the rural research trust funds) which made decisions about the joint financing of research using common pooled funds collected by the state on behalf of the producers.

By 1990 the rural research sector had been thoroughly corporatised as the majority of the research trust funds are now research corporations with the capacity to raise funds in financial markets. The Hawke Government also corporatised decision-making about CSIRO in a series of restructuring initiatives designed to re-orient the country's largest research organisation towards the production of scientific knowledge for use in economic production. The relationship between the subgovernment and CSIRO is, strictly speaking, one of *concertation* because of the singular CSIRO executive structure. However, the size and complexity of the Organisation, the indirect nature of the government's coercion, and the way in which the subgovernment was restructured to include commercial interests, favours the corporatist category as the most adequate explanation of current relationships. In the manufacturing sector the shift to corporatism has not occurred as organised interests remain weakly associated. However, the pressure pluralist networks have changed to become clientele pluralist as government has become dependent on businesses to allocate efficiently the considerable financial resources foregone through the tax concession scheme.

The relationships within the higher education sector would appear to be concertative. Here the relationship is a closed network in which an autonomous state has created a single agency to allocate funds for research in the sector. At one stage in the mid 1980s the relationship almost became *state-directed* but the fact that the subgovernment always involved the higher education research community in decision-making about the restructuring; and that the significant actors in the restructuring process (ASTEC, the ARGS Committee) were members of the existing subgovernment means that the situation was not entirely one of state-imposed change. However, there are elements of a *state-directed* network in the way in which the executive core has maintained control over the Co-operative Research Centres within the Department of Prime Minister and Cabinet despite the promise to assign control to an 'appropriate' agency once the scheme was established.

In all sectors there have been moves by subgovernment and the executive core to include market interests and procedures in decision-making in science policy. The general shift in science policy interaction between 1965 and 1990 would therefore seem to be from clientele pluralism to corporatist networks.

The actor-categorisation aspect of the policy community approach has been further augmented in this thesis in order to expand the explanation of change. The novel categories of *international attentive public*, and *executive core* are introduced in order to distinguish, respectively; the influence on national science policy of significant extra-national actors; and the capacity of significant actors in national central agencies to veto action in a policy community of which they are not regular members. In this way the thesis addresses two more of the conceptual 'challenges' considered by Atkinson and Coleman to be necessary for further development of the approach. These are: theorising between communities and broader political institutions; and integrating international arenas of decision-making into the approach.[1] As mentioned above the category of international attentive public has been useful in this analysis because of the close integration of the domestic and international scientific communities. However, there are not many areas of modern government activity which are immune to international influence, and the category would be of use in analyses of other policy arenas.

Similarly, the notion of the executive core is of particular utility in these days of steady state resources and government by program management, particularly as the control of financial resources is increasingly undertaken by departments of finance as well as traditional Treasuries. Such central agencies as the Department of Finance and the Expenditure Review Committee of Cabinet play a considerable role in defining overall budgets and suggesting areas of possible cost-saving.

This thesis also introduces the category of *superstructural subgovernment* as a logical extension of Pross's subgovernment. While this may seem to complicate an approach whose major appeal lies in its simplicity and directness of applicability, it helps to explain the increasingly centralised and complex structural changes that occurred within the highly segmented science policy community. The science policy community has shifted to a more stratified form. The most significant decisions about the allocation of resources to the production of scientific knowledge are now made by specialised policy agencies in a superstructural subgovernment comprising both scientists and non-scientists, according to prescribed techno-economic criteria of relevance to economic production. Other policy agencies are still identifiable with the sectoral subgovernments of science policy but the degree of autonomy they have retained varies according to the perceptions in the superstructural subgovernment about their centrality to economic restructuring.

A deficiency in the policy community approach, also noted by Atkinson and Coleman, is that it lacks a perspective which will allow an explanation of the analysis of the: '...relationships of power and dependency that transcend and color individual

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1 Atkinson & Coleman, 'Policy networks, communities and problems of governance', p. 163.

transaction.'[2] This thesis attempts to overcome that problem by incorporating into the policy community approach Clegg's notions of control over structure, resources and ideas. Here, the fundamental unit of analysis is the interaction which takes place between significant actors in the policy arena. This interaction is structured into networks of relationships which change through time and around issues. A policy community may contain several such networks. The interaction which takes place within the networks is motivated by the desire of significant actors to obtain or maintain control of these vital factors. Such a concept of power is useful in explaining why structures are established or not established in certain ways; in explaining the differential distribution of resources; and in explaining why certain ideas remain dormant and others germinate. The incorporation of this power perspective into the policy community approach allows the analyst to build up an understanding and explanation of the complex interactions of modern, globalised policies by observing and mapping the movement of actors, resources and ideas through geographical and organisational space and through time.

In the science policy community the exercise of power is oriented around the exchange of knowledge and resources, mainly ethical and financial. Chapter three discusses the way in which scientists have reacted to new ideas and techniques concerned with the organisation of research. It has been difficult for many scientists to separate creativity, and political and financial accountability. However, the example of the CSIRO Division of Wildlife and Etymology given in chapter seven shows that creativity and accountability are not mutually incompatible. Chapter four shows how new decision-making structures and programs evolve in response to these new ideas with such concepts as *research foresight* borrowing heavily from policy process theory. Chapter five traces changes in the pattern of allocation of public resources to research activities and documents many instances in which a government with a techno-economistic ideology about science imposes on researchers the need to compete for public funding, and the need to consider the private sector as a source of finance. The thesis shows that scientists' control over structures, resources and ideas has diminished as the paradigm of scientists' autonomy has been superseded by the paradigm of economic relevance.

The thesis thus links the exercise of power to the value systems and ideologies of the actors. As Atkinson and Coleman suggest: '...there is no reason why networks cannot also be distinguished in terms of ideological resources'.[3] In this thesis the notion of ideology is linked to economic and political change in explaining action in the political system and the science system. It was shown in chapter two how various political ideologies have shaped science policy in Australia, and how colonialism and conservatism have gradually given way to techno-economism. Merton's concept of

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2 Ibid., p. 161.
3 Ibid..

the ethos of science, contained in four principle norms guiding the behaviour of scientists, is used to explain why scientific actors and political actors are so often in conflict over science policy objectives. Scientists believe that autonomy is essential for creativity. Political actors argue that research is simply another area of activity funded from the public purse and therefore should be accountable to political norms. In the 1980s the ideology of techno-economism proved more compelling in enforcing such norms than previous conservative ideology because of the inherent characteristic belief in the legitimacy of government intervention in social activity directed towards national interests.

2. Changing Patterns of Interaction

Within the science policy community in Australia, patterns of control over rules, resources and ideas have changed quite markedly in the 25-year period under examination here. Overall there has been a shift away from control by elite individuals or elite groups of scientists, interacting informally with significant actors in the political system to maintain autonomous research organisations, towards a more centralised and corporatised control of generalised research programs by mixed committees of scientific and political actors.

The thesis examines four separate subgovernments of science policy, each with its attentive public, and identifies each as having developed distinct patterns of interaction. The analysis shows that the decisions made in a particular science policy subgovernment traditionally tended to be unco-ordinated with the other subgovernments, and this has largely remained the case despite the establishment of a superstructural subgovernment consisting of overarching techno-political agencies co-ordinating and controlling resources and ideas within each sector. The changing patterns of interaction have produced different outcomes in each of the subgovernments of the science policy community. These outcomes are summarised in table 9.1.

In 1965 the higher education subgovernment consisted of a few senior scientists, located in elite research organisations and universities, who were able, by influence and veto, to control four key areas of action: ideas about the way the higher education research system should be organised; the socialisation, indoctrination and training of new scientists; the development of funding agencies; and the allocation of funds from those agencies. Individual grants programs proliferated on an ad hoc basis to suit scientists' disciplinary interests. Since then there has been a rationalisation in which responsibility for most of the programs (excluding the NH&MRC)has been relocated to a single agency covering a multiplicity of disciplines and operating under increased ministerial control. The selection process has been made more competitive by channelling recurrent research funds into competitive grants, and by opening up the higher education research system to a wider range of institutions. Now research projects are increasingly selected and designed by teams of researchers often in collaboration with industry and public sector research organisations.

Table 9.1: Changing patterns of interaction and their outcomes in Australian science policy, 1965-90

	Resources	***Restructuring***	***Evaluation***	***Knowledge and its application***
Higher Education	recurrent funds + special research grants ↓ ARC & CRCs	individual researchers & universities ↓ research teams & Co-operative Research Centres	peer-reviewed excellence ↓ mixed academic and business committee review	individual publications & extension services ↓ publications, patents & research companies selling intellectual property
CSIRO	appropriations + 'contributions' ↓ 30% external fund generation	discipline-based divisions ↓ industry aligned institutes	individual researcher & problem-centred evaluation ↓ organisational, universal criteria based selection	publications & extension services ↓ publications, contracts & collaborations
Secondary	AIRDS grants ↓ tax concession & IR&D grants	firm-based ↓ contracted & sponsored	product level ↓ industry level	imported know-how ↓ indigenously produced know-how
Rural	levies ↓ levies & venture capital	funds ↓ corporations	scientists & producers ↓ producer-market	communal extension ↓ private intellectual property

In 1965 CSIRO as a subgovernment dominated the Australian science policy community through the influence of its scientists in the allocation of funds, in the formulation of ideas about the way in which the production of scientific knowledge should be organised and in the shaping of government objectives for the application of research results. Although defence research had a larger budget, the scientists in CSIRO had virtual autonomy over the selection, organisation and dissemination of new scientific knowledge in the non-defence and non-medical sector. The CSIRO Executive expected minimum political interference in the allocation of resources to maintain the Organisation, and the idea of non-scientists being involved in the management of research was an anathema. Even the leaders of the industries which CSIRO was legally bound to support were regarded by scientists as incapable of making strategic decisions about future industrial needs.

For CSIRO changing policy outcomes have resulted in a re-orientation of the Organisation from ad hoc problem-solving for industry, and the pursuit of research projects because of their intrinsic scientific interest, to proactive selection of research projects which can be commercially exploited in Australia. The changes involve a re-alignment of the research divisions into institutes which closely parallel sectors of industrial economic production; rationalisation of the Organisation's appropriation funds by restricting annual increases to those necessary to maintain real value; the imposition by government of the requirement that thirty per cent of the Organisation's total expenditure should be from external sources; and the development of a standard set of prioritisation criteria by which research proposals in all divisions must be evaluated.

The changes in the manufacturing industry subgovernment have perhaps been the most dramatic in terms of their impact on the amount of research undertaken. This sector of economic production has traditionally lagged behind the others in terms of the level of investment in research and development. Innovation has been imported rather than indigenously produced. In 1965 there was no direct government subsidy to manufacturing industry research beyond the tax deductions normally allowed for economic production. The system of tariffs on imported technology protected manufacturers from the need to compete with technological innovation developed overseas. The industry research and development incentives introduced in 1968 favoured large companies with existing research and development facilities. There was no attempt to prioritise among areas of production or to evaluate the capacity of the firm to carry the new knowledge through to viable commercial products and processes.

By 1990 research and development as a percentage of production had increased in all manufacturing industries but still lagged behind the OECD average except in electronics and computing, non-electrical machinery and ferrous metals. The incentives for manufacturing firms to invest in research and development had broadened to include research into marketing and promotions. The grants system had been developed to cover three main objectives: to encourage firms not formerly undertaking research to do so; to encourage firms to collaborate in pre-product research; and to foster co-operation between private firms and public sector research organisations. In addition scientists in public research organisations were being encouraged to involve potential developers in the early stages of their research. The 150 per cent tax concession was introduced in 1985-86 and was a major breakthrough in manufacturing science policy because it was a formal recognition by government of the need for ongoing and flexible support for firms which may have to wait for ten years before being able to appropriate the gains on their research and development investment. One of the results has been a decreasing dependence on overseas technical know-how and increased overseas payments for Australian technical know-how.

In 1965 rural research activity had been collectivised for many years. Trust funds existed for the four major industries (wool; wheat; meat and dairy) as well as for a few minor ones. The Commonwealth Government acted as agent for these rural industries in four ways: using its tax powers to collect compulsory levies from producers; adding public sector contributions; administering the trust funds in which the research monies were held; and overseeing fund management. There was no government direction about the use to which the funds were put. This was decided by the members of advisory committees which managed the trust funds. Scientists and producers were the most powerful members of the rural subgovernment and their interests often clashed as they tried to manipulate resources and structures in order to control the research undertaken. The majority of rural research was undertaken by CSIRO and State department laboratories. The resultant knowledge was disseminated through extension services provided by State Governments subsidised by specific purpose and special appropriation funds from the Commonwealth Government.

By 1990 the trust funds had been corporatised to allow rural industries to raise extra funds for research from private, non-producer sources. This has decreased both producer and researcher control in favour of agribusiness interests. At the same time appropriation funds for rural research in CSIRO, particularly for rural manufacturing, were decreased. The result has been increasing privatisation of the results of rural research formerly considered to be a public good.

Many of these changes occurred during the last eight years of the twenty-five year period. The higher education research system remained fundamentally unchanged until the termination of the binary system, and the establishment of the ARC and the restructuring of research funds in 1987-88. The organisational and funding changes to CSIRO which began tentatively in the early 1980s were completed with statutory amendments and changed external financial expectations in 1986. Similarly the incentives for manufacturing research and development were foreshadowed in the sunset clauses of the AIRDIS scheme but the old system remained in place until 1986. In 1985 the first of the rural research trust funds were corporatised, and control of the minor funds was co-ordinated through the Rural Industries Research Corporation.

However, the ideas for these developments were not entirely new. Many had been brought to the attention of governments at regular intervals over the twenty-five year period. For example, the income tax concession had been discussed in the early 1960s when a similar scheme had been introduced into Canada, and again at the end of the 1970s when science policy began to come under increasing economic scrutiny. Research centres involving co-operation between higher education, industry, and public sector research organisations had explicitly been suggested by the Vernon Report in 1965. The inclusion of industrial experience as part of the training of new scientists has often been advocated as a way of broadening the relevance of basic research conducted in universities and CSIRO. Likewise, the first OECD report on science policy in Australia in 1974 recommended a wider definition of research and development activity to be subsidised through the incentives scheme. Scientists reporting on the dissemination of research findings in 1962 pointed out that the international publication of research which could be commercially exploited is virtually a 'charitable donation to the rest of the world'. Nearly twenty years later the same observation was made in a detailed analysis of rural research by economists. In 1966 Encel and Inglis had suggested that the results of research conducted in government laboratories was unlikely to be patented or developed unless governments intervened to ensure that it was done. In 1964, Boas, Chief of Tribophysics at CSIRO, suggested that Parliament should have a science and technology committee, and scientists should be employed at Cabinet level to ensure that the political system was aware of the way in which the results of research could be used to benefit the nation.[4] The question now needs to be asked: why did the changes not occur until the 1980s?

3. THE REASONS FOR CHANGE

This study argues that the causes for the implementation of science policy changes in the 1980s rather than the 1960s or 1970s can be found in a co-incidence of fit among three events: the election of a Commonwealth government with a political ideology of techno-economism; a receptiveness in the subgovernment to the articulation of ideas within the international attentive public about the rationalisation of science policy; and the decreasing availability of public sector resources as commodity prices fell and the technological balance of payments deteriorated. The election of a government, in which the most significant actors in the science policy arena believed that the restructuring of economic production should be science-based, meant that these actors were prepared to exercise power, in the form of their capacity to control rules, resources and ideas, in order to achieve these techno-economistic outcomes.

Although Whitlam had expressed a similar ideology in the years leading up to the election of an ALP Government in 1972, this policy rhetoric had not been translated into action because Whitlam had used science policy as a device to expose the incapacity of the Liberal-Country Party to address techno-economic issues of industrial restructuring. He was not committed to effecting real change in the production of scientific knowledge in Australia. The science portfolio was combined with responsibility for the independence of New Guinea and given to a politician who was much more interested in foreign affairs than science.[5] Whitlam himself, having spoken extensively on science policy in Parliament between 1964 and 1972, barely mentions science in his published account of his governments. This apathy allowed influential scientists to retain control of the subgovernments and to resist innovation. The postponement of the re-establishment of a science policy advisory committee, and the 'capture' of the Science Task Force Report by academics advocating Polanyi-style autonomy are examples of this resistance.[6]

Fraser eventually established ASTEC but his conservative ideology delayed the implementation of techno-economistic recommendations coming from the numerous

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4 Boas, 'Science in Industry', p. 236.
5 Morrison, Interview, 1.11.89.
6 Whitlam, *The Whitlam Years 1972-1975,* Viking, Sydney, 1986.

government inquiries into the science system throughout his terms of office. The initial ASTEC Report; the Birch Report into CSIRO; the Industrial Assistance Commission Inquiry into Rural Research; and the evaluation of the AIRDIS scheme all documented the need for restructuring the publicly funded production of scientific knowledge to fit the needs of the changing Australian economy.

It was not until the election of the Hawke Government in 1983 that there was a coincidence of commitment to techno-economism in the form of the appointment of Barry Jones as Minister for Science, and the receptiveness of significant actors in the policy community to his vision of the way in which the science system should be restructured after years of incrementalism. This commitment and receptiveness was necessary in order to overcome the intransigence of those members of the subgovernment and attentive public whose previous control of the system was under threat. Jones' commitment to effecting change in the production of scientific knowledge in Australia, coupled with his lack of a factional political base, alienated him from both scientific and political actors and lead to his eventual demise as minister, but many scientists joined the public in bemoaning the loss to the ministry of a politician so dedicated to the restructuring of Australia's economic production.[7]

Jones' restructuring rationale was based on the Australia's worsening terms of trade. The prices of commodities which composed the majority of Australia's exports were falling. Between 1980 and 1983 the real value of sugar fell by 64 per cent; the price of wheat by 49 per cent; the price of wool by 35 per cent; and the price of coal by 22 per cent.[8] At the same time the pace of technological change through computerisation was increasing the price of imported goods. The resulting deterioration in the technological balance of payments, together with Australia's broader structural economic problems, gave added impetus to Jones' arguments about increasing the scientific and technical base of Australia's economic production. He immediately enlarged the membership of subgovernmental agencies which controlled the allocation of resources to research to include entrepreneurs and scientists with experience in commercialising new, high technology processes and products. This opened the gates to a radically corporatised science policy.

4. A Taxonomy of Science Policies

We can now compare this new type of science policy with other possibilities. Four distinct types of policy can be identified: elitist; nationalistic, corporatised; and market-oriented. The taxonomy is based on the understanding that policy is a result of an affinity between certain types of ideas, ideology and interaction.[9] Table 9.2 specifies the types. Two of the types - elitist and corporatised - have predominated in the

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7 Phillip Adams, 'Australia cries: bring back Barry', *Weekend Australian,* 19-20 May, 1990, p. 2.

8 Foster and Stewart, *Australian Economic Statistics,* p. 286.

9 The types of interaction used are those articulated by Coleman and Skogstad to categorise policy networks. Their typology given in table 1.3 in chapter one.

Australian governments. The third, market pluralist, would be the choice of a government committed to neo-classical theories of allocating public resources. A fourth - nationalistic - occurs when governments or their agents assume total control over the science system.

Table 9.2: A typology of science policies

POLICY TYPE	*IDEOLOGY*	*IDEAS*	*INTERACTION*
ELITIST	CONSERVATIVE	SCIENTIFIC AUTONOMY	CLIENTELE-PLURALIST
NATIONALISTIC	SOCIALIST	COLLECTIVISM	CONCERTATIVE
CORPORATISED	TECHNO-ECONOMISTIC	POLITICAL & ECONOMIC ACCOUNTABILITY	CORPORATIST
MARKET-ORIENTED	LIBERAL	ECONOMIC RATIONALITY	PRESSURE PLURALIST

Elitist science policy tends to emerge when conservative ideology encourages ideas of scientific autonomy about the way publicly-funded research is organised, and in decision-making about the overall objectives for the use of scientific knowledge. Actors are allowed to participate in policy-making and clientele pluralist networks prevail as government actors come to depend on the expertise, contacts and knowledge of elite scientists to formulate and evaluate policy. Under conditions of scientific autonomy there is minimal intervention or co-ordination by government of the priorities or management of researchers.

By contrast, nationalistic science policy involves the control of all research through a centralised political agency interacting through concertative networks with a unified science system operating on collective principles of socialised welfare. The science system becomes a national icon and the principal objectives for science are the glorification and justification of the state. This is the type of science policy envisaged in the works of Bernal discussed in chapter three. Science policies which exhibit the characteristics of concertation are rare in liberal democracies because it is doubtful that under such political systems scientists will be totally deprived of participation in decision-making about the way scientific knowledge is produced and applied. Only in wartime has such control been imposed on scientists. However, elements of concertative science policy can be found in defence science where scientists, working under the control of the armed forces, operate in a science subsystem isolated from the norms and values of the international as well as the national scientific community.

Corporatised science policies are developed by governments wishing to co-ordinate research on a national level towards the achievement of primarily economic rather than cultural goals. Governments co-opt the leaders of economic and scientific production to develop and implement science policy.[10] They use political power in the form of control over the rules, resources and ideas for science, to orient the production of scientific knowledge towards economic objectives. Scientists are expected to select and organise their work according to political and economic as well as scientific criteria. Resources are therefore allocated by governments according to project evaluations of relevance to economic needs. Groups participate in the processes of prioritisation, selection and evaluation, but overall objectives are decided by government.

Market oriented science policy means that governments allow market forces to decide the allocation of resources to science. The objective is also broadly techno-economistic, but governments' role is minimal and restricted to creating a productive environment free of government-imposed constraints on the flow of capital, materials and labour. Networks take a predominantly pressure pluralist form in which groups approach government independently, and are assigned an advocacy role by autonomous state actors. For those situations in which market failure occurs, for example, the production of basic scientific knowledge, some government support may be available through the university system or through government sponsorship of research in private laboratories. Scientists organise the production of new knowledge, which is commercialised either through the 'market pull' of the need to innovate or reduce the costs of production; or through 'science push' by breakthroughs in scientific knowledge being introduced to industry by researchers. Firms may join industry associations which fund pre-development research on a collective basis.

The general pattern of change in science policy in Australia between 1965 and 1990 is a one of a shift from elitist to corporatised science policy. The elite scientists of Menzies' era have been superseded by the science policy committees and councils of the Hawke governments. The autonomy of CSIRO, and the industrial and university granting schemes have been replaced by mechanisms of accountability, albeit couched in the policy rhetoric of autonomy. Resources which had been allocated to the research projects chosen by scientists must now be justified in techno-economistic terms of relevance to economic production. Scientists in significant

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10 In categorising this type of science policy the author decided to use the term corporatist to designate the type of policy occurring when interaction is mainly of the corporatist type described by Coleman and Skogstad. This is because the use of the term immediately conjures up concepts of co-option, exclusion, mixed membership, and participant commitment to implementation which are central to this type of policy.

positions in peak organisations are co-opted into subgovernments as full-time policy makers.

The change has been most marked in manufacturing research policy which, in 1965, was closest to the market model (given the constraints of tariff protection on innovation). In 1990 manufacturing science policy is effectively corporatised with wide industry representation on the committees, councils and boards of management which allocate resources to research and development. Through the mechanism of the grants schemes governments can direct resources towards research which will restructure industry. Through the mechanism of the tax concession governments can create the conditions which may encourage in Australian manufacturing the innovative ethos which has been stifled by protectionist industry policies and the inertia of conservative political ideology.

Market-oriented science policy has not yet been experienced in Australia. Such a science policy would logically involve:

- the abolition of the Prime Minister's Science Council and all science policy co-ordinating committees;
- the complete autonomy of scientists in research organisations, including the allocation of resources and the selection and management of research projects;
- the complete privatisation of CSIRO and other public research organisations;
- the abolition of the 150 per cent tax concession to deter the undertaking of non-appropriable research by business;
- the withdrawal of the government component from rural research corporations;
- cessation of subsidy for extension services to rural and manufacturing industry;
- payment by rural and manufacturing producers for environmental research;
- restriction of the support of science by government to the production of basic science in universities;
- non-eligibility of applied research projects for government higher education research grants;
- cessation of government subsidisation of collaboration between industry and higher education;
- restriction of funds for research (including medical and defence) to that which cannot be purchased for less cost overseas; which is not available overseas; or which is required in order to adapt scientific knowledge purchased overseas to Australian conditions. This research would be undertaken on contract in private laboratories.

The success of such a policy would rest upon three basic assumptions: firstly, that scientists would produce research results in the form required by the market and that scientists would actively promote their work to firms; secondly, that firms, rather than importing new technology, would actively seek to use scientific knowledge produced in Australia in order to innovate; and thirdly, that scientists and industrial producers would reach an accommodation on the conflict between the ownership of intellectual property and the publication of research results.

5. Future Policy Options

An evaluation of the effectiveness of science policy is not a central objective of this thesis which instead concentrates on explaining how and why policy has changed. However, having reached an understanding of the dynamics which underlie observed changes, it is tempting to anticipate what further changes may occur.

At the end of 1990 there had been seven years of increasingly corporatised science policy in Australia. Considerable government-induced structural change throughout the science system, informed by ideas of techno-economism and combined with new techniques for the prioritisation, selection and evaluation of research activities have already produced some 'positive' outcomes in the forms of: an improving technological balance of payments; greater investment by manufacturing and other industries in research and development; a closer alignment of CSIRO to the needs of economic producers; and, through the CRCs and other mechanisms, a similar alignment of the higher education research system. Rural industry in particular stands at the threshold of a revolution in production based on genetic engineering and other advances in biotechnology which can be commercialised through rural research corporations. The corporatist ethos fits an ALP ideology that legitimates government intervention in the relationship between the science system and economic production. With the re-election of the Keating government in 1993 it is likely that science policy will at least remain corporatised in type, with, if anything, increasing prioritisation of portfolio allocations to research by the superstructural Co-ordinating Committee on Science and Technology.

It is difficult to judge how much a Liberal-National Party government would have moved towards a market-oriented science policy. The science policy announced just before the 1993 election is the most explicit of a series of vaguely-worded statements which the Coalition has developed. The 1993 statement emphasised the effects of tax restructuring in liberating private industry funds for investment in innovation. That part of the policy is certainly market-oriented and free of government intervention. However, it is unlikely, given the conflict that a corporatist science policy provoked between the political and science systems, that the L-NP policy rhetoric of allowing industry to lead the way in the prioritisation of research would in fact be politically feasible.

The implementation of such a model would create considerable conflict in the science system and among private producers whose research and development activities have previously been subsidised by government. It is likely that such a policy would be short-lived and would rapidly revert to elitism as scientists and industrial producers used political influence to allocate public resources to support their activities in the name of national well being; or to corporatised science policy as governments attempted to redress a worsening technological balance of payments as industries reverted to old habits of importing technology once the carrot of government subsidies was removed from science policy.

In addition the introduction of such a science policy in Australia would result in the demise of basic research. There is very little tradition within the Australian science system of private sponsorship of basic research.[11] There are no large philanthropic foundations as there are in the USA; and, until recently, no tradition of business interaction in university research as in Germany. The prolongation of the British colonial ideology in universities has meant a high level of dependence on government support. Under a market-oriented science policy, governments would only support basic research in the higher education system for three purposes: to retain the services of researchers of a sufficient calibre to train new scientists at a lower cost than could be bought overseas; to maintain a pool of knowledge adequate to adapt and apply scientific knowledge purchased outside Australia; and to meet the basic science requirements of industrial producers.

Therefore it seems to be inevitable that there will be a continuation of government support for the production of scientific knowledge for private as well as public purposes. The most likely changes over the remaining years of the twentieth century will be: the incorporation of control of the prioritisation of medical and defence research into the superstructural subgovernment; and the expansion of the concept of research and development as an export industry as well as a form of aid to developing countries.

The first development will increasingly be perceived by governments to be necessary as medical research consumes an ever-increasing proportion of public resources allocated to research without the wider spectrum of evaluative decision-making based on economic as well as cultural criteria. The second development, that of exporting the production of scientific knowledge developed in Australia, holds the greatest potential economic benefits for Australia. The rationale would be to sell the capacity to generate scientific knowledge as well as the knowledge itself. It would involve leasing sections of major public research organisations to overseas customers who wish to purchase the productive capacity of Australian scientists in a relatively

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11 ABS data shows that, in 1989, only 11 % of all research and development expenditure on pure and strategic basic research originated from the private sector.
Australian Bureau of Statistics, *Research and Experimental Development: All Sector Summary 1989-90.* Cat no. 8112.0, p. 5.

low-cost environment. This will be most pronounced in the areas of biotechnology, rural, mining and environmental research, because of the expertise already available. Likely customers would be small or newly industrialising countries which cannot afford to establish research capacities in these areas. If scientists' creative capacities can be directed in this way then, instead of being the 'quarry of Asia', Australia might become the laboratory for the newly-developing countries of the Asia-Pacific region.

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